

THE BACKYARD FOUNDRY

B. Terry Aspin



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NUMBER

25

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Illustrated by the author



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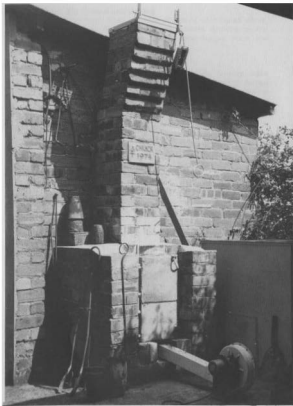
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The backyard foundry.

CHAPTER 1

Introduction

The elementary process of casting metal in a sand mould is very simple and it is a craft which has been practised for centuries in one form or another. Even today, modified as it has been to conform to modern technology, the process is recognisable in most of its traditional features. To some readers of this book, however, perhaps even the basic principles will be unknown and thus, it is hoped, this first chapter will serve to provide a clear view of the fundamental issues involved.

Metal is melted and when it is in a proper state of fluidity it is poured into a cavity in damp sand, where it solidifies and takes the permanent shape of the inside of the cavity. Therein is the essence but, of course, there is a good deal more to it than that, and it is probably the formation of the interior of the sand cavity to the required shape that occupies most of the skills of the foundryman. The same would be true whether he be a sophisticated technician or a rank amateur.

Nature provides in abundance the essential ingredient for mould making. Sand, which has formed a geological strata for eons of time and which is excavated or, indeed, lies on the surface of the earth in the form of loose particles

or soft rock, is the basic element. Often it has a reddish colour imparted by the metallic oxides combined with it and it may also contain clays. It is these included materials which render the sand suitable, without further processing, for use in the foundry. The oxides and clays with added moisture bind the sand together to form a plastic, mouldable material which readily holds the shape imparted to it by the pattern. In the modern foundry there are also synthetic sands and other refractory materials used. They are often combined with clay, such as bentonite, which is imported into this country, added in such proportions as to produce an ideal plastic quality and unimpaired permeability to allow the free escape of gases.

The pattern for forming the mould, at its simplest, is nothing more than an exact replica of the object to be cast. It may even be a previously cast specimen. For reasons of economy of effort it is usual to make the pattern in a material which is easy to manipulate into the desired shape. Wood, plaster, wax, clay, etc., may be used with good results, sometimes separately, sometimes together. A new mould is made from the pattern in the sand each time a casting is

squired. The mould is destroyed when the solid metal is extracted but the pattern remains intact for making a further mould, and so on.

The same sand can be used over and over again. It is true that over a period of time, as more and more of it becomes burnt in contact with the metal, it does tend to deteriorate and lose much of its bond. The 'bond' of moulding sand is its ability to cling together in a mass when damp. In good sand the bond will endure after the sand has dried. Thus it will also have a 'dry' bond. With infrequent use in

the home foundry it is unlikely that this deterioration will present much of a problem. Industry often regenerates its sand by re-milling with added clays.

In the small foundry, sand, when not in use, can be stored dry and re-tempered with a small amount of added moisture each time it is required. Since it has to be stored somewhere – wet or dry – it is an obvious advantage to keep it in a rustless bin, lidded to prevent evaporation of the moisture. After use each mould as it is broken up is returned to the bin and, at the end of the day, the sand is sprinkled



Putting the sand through a quarter inch mesh riddle. The sand is stored in the bin behind.

with a little more water to make up for that driven off by the heat. The moisture can thus, for the most part, be retained in the sand with the bin tightly lidded until the sand is needed again.

For the next use the sand needs to be re-tempered, that is to say, returned to a good moulding consistency with the right amount of moisture. Since it has retained some dampness, added water if needed is easily absorbed by the sand which, to give it good handling, is passed through a riddle of about $\frac{1}{4}$ " mesh. This effectively removes bits of unwanted material, dirt, stones and splashes of old metal, etc., and the sand is then ready for re-use.

Wet sand cannot be used for moulding and much less for casting, so the addition of water must be watched very carefully. If absolutely dry sand was available to start with, moisture content could be gauged by proportion, which may then still vary between 4 and 8%.

The alternative, when some moisture is already present, is to test the sand by hand as the re-tempering proceeds. Squeeze a handful of sand into a ball. In good condition it will hold together without cracking but, when the hand is opened, it should not adhere to the palm. There is no doubt, however, that experience alone provides the best guide.

It is an excellent idea to have a second bin available to receive the tempered sand as it is riddled and it does no harm to do the tempering one day and the moulding the next, providing the second container can also be tightly closed.

A mould made and poured in damp sand is known as a greensand mould.

Making a greensand mould

The following sketches illustrate the moulding process right through and commence with a sketch of the pattern it is

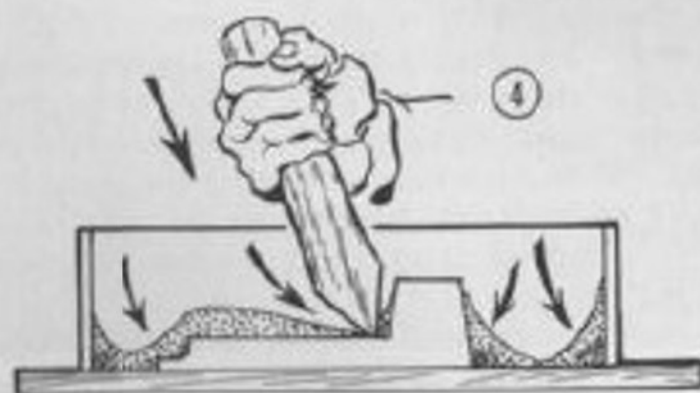
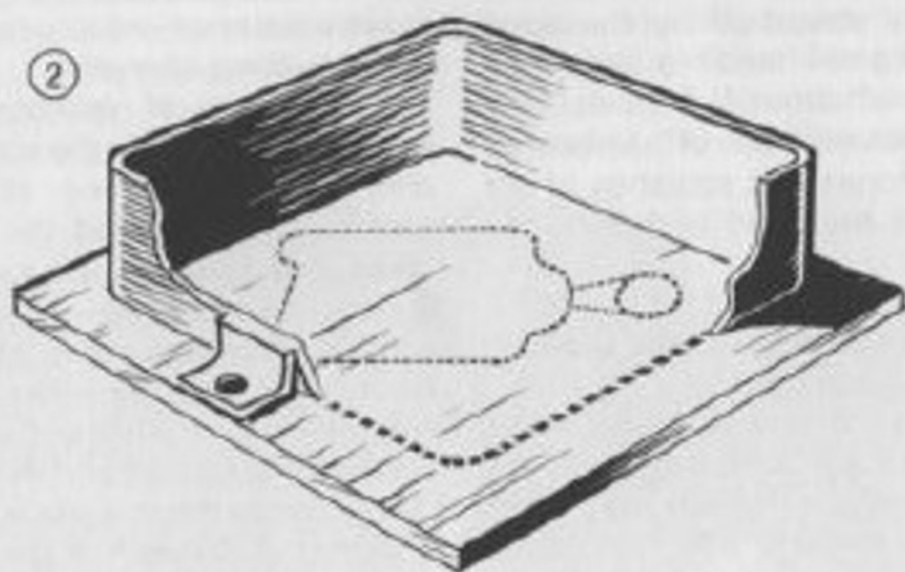
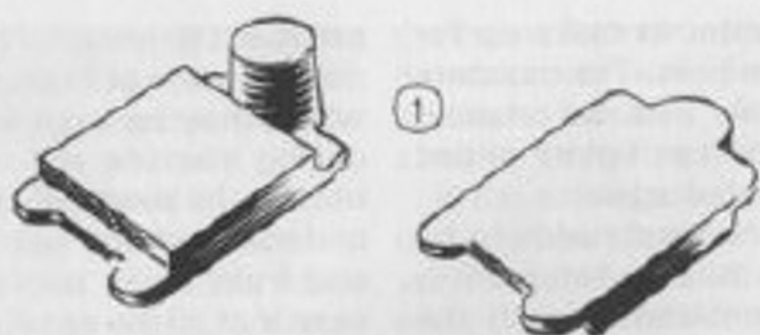
proposed to mould. This, purely from the point of view of illustration, is a soleplate which may be used for a small pedestal drilling machine and carries a solid boss to take the eventual pillar, sketch 1. The underside of the pattern is also shown and from these two sketches it can be seen that all the detail of the pattern is on one side or, in this case, the upper part. The reverse is completely plain and flat; a circumstance which much facilitates the moulding operation.

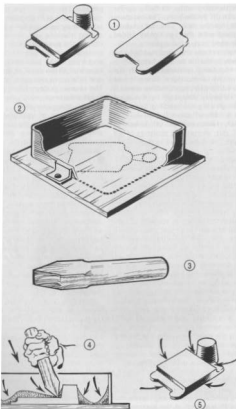
Some form of receptacle is usually employed to contain the sand of the mould and, at the same time, allowing it to be packed tightly round the pattern. This takes the form of a box in two parts which, in foundry language, is known as a flask. The two parts of the flask are located, one to the other, by dowels or pins and this allows the flask to be opened and closed and at the same time retain the correct register.

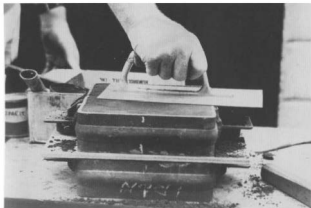
Sketch 2 shows half the flask, without the pins, resting on a board and, indicated within it by a dotted line, the position selected for the pattern. This should be chosen to give the best clearance between the extremities of the pattern and the edge of the box. The small dotted ring indicates the eventual location of the pouring hole – the sprue – relative to the pattern.

Sketch 3 is the ramming stick, wedge shaped at one end, flat at the other, for compacting the sand in the box and round the pattern. The arrows on sketches 4 and 5 indicate where the wedge end of the ramming stick is utilised to press the sand into angles and corners of the pattern and the box, where simple vertical packing would tend to leave the mould loose. Loose sand is public enemy number one in the foundry.

The half box is then filled up with packed sand and the top strickled flat







Levelling the finished mould with a plasterer's float.

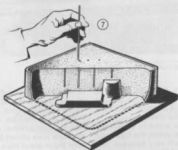
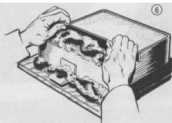
and clean, sketch 6. Surplus sand is brushed away and the upper surface trowelled smooth. A plasterer's float is a useful implement for this.

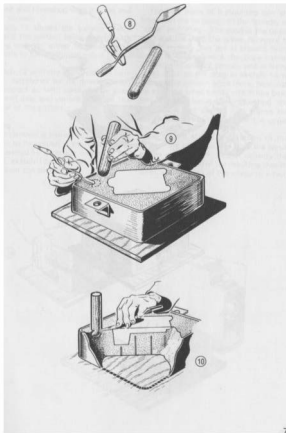
According to the metal to be melted, the temperature at which the liquid will enter the mould will vary between perhaps 1,000°F (538°C) and 2,500°F (1,371°C) so that considerable pressure of steam and gas is generated within the mould cavity. The permeable nature of the sand allows this to escape but the mould can be further ventilated with advantage by piercing the sand vertically above the area of the pattern with the aid of a piece of wire. A small screwdriver is often used, being readily to hand. As a general rule, perhaps, the hotter the incoming metal the better the sand needs to

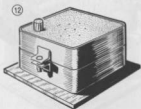
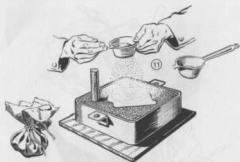
be ventilated. Sketch 7 is a cross section of the vented mould, which is now inverted on the board.

The flat underside of the pattern is now exposed to view. Among the group of simple tools shown in sketch 8 can be seen the rounded stick, about an inch in diameter, which is itself in actual fact a kind of pattern. It is used to mould the sprue.

In sketch 9 a small recess is formed with a trowel about half an inch or so from the pattern at a point chosen as suitable to receive the flow of metal. The ball-end of the stick is here embedded in the sand to a shallow depth of, say, about a couple of centimetres to retain it in a vertical position. In sketch 10 the sand round the base of the stick is being







replaced and firmed up with the flat end of the trowel.

Sketch 11 shows the surface of the sand and the pattern being dusted with 'parting powder' either by means of a fine sieve or the traditional calico bag as shown.

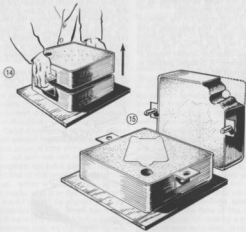
Sketch 12 is of the complete box now closed, registered by its dowels, filled and rammed up with sand. It has been smoothed over and vented ready for the removal of the pattern.

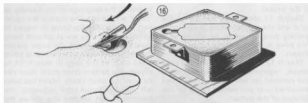
Rapping

Pattern removal is known as rapping and the first to be rapped is the sprue stick. It is loosened by a circular motion of the fingers, sketch 13, and then, with care, withdrawn completely.

The two parts of a moulding box are known in the language of the foundry as 'cope' and 'drag'. The cope is the upper part and the drag the lower in regard to which way up they are at present being used. In this instance the cope carries the register pins or dowels and is being lifted clear of the drag in sketch 14 to expose the pattern once more. Now can be seen the small cavity which has been left by the sprue-stick adjoining the pattern. A part section also shows the sprue hole left in the sand of the upper box, sketch 15.

Sketch 16 shows the cutting of the ingate, the canal leading from the sprue to the mould cavity, again utilising the spoon-shaped end of the moulding trowel. Inset is a diagram of the shape to which





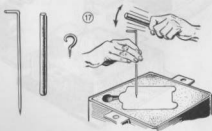
this channel is cut. The wider part is at the bottom end of the sprue, tapering towards the pattern. The smaller section here makes for the easier removal of the unwanted metal from the casting, whether broken off or sawn, but the ingate must not taper so severely as to impede the flow of the metal.

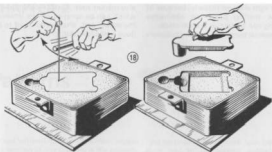
The box is now ready for the removal of the pattern. For this operation three simple tools are used – the pointed rapping bar, the striker and the screw hook or some other convenient means of lifting the pattern. A dropped pattern at this stage would be a disaster.

The sharp point of the rapping bar is

tapped into the pattern as close as can be estimated to the point of balance, sketch 17. In the example shown the most effort will probably be needed to loosen the deepest part of the pattern which is the pillar boss. At this stage the rapping will be seen to loosen the sand in the immediate vicinity of the pattern. As the pattern is lifted there is the tendency for these particles to fall inwards. To prevent this as far as possible a little extra water is applied with a camel hair or other soft brush immediately round the edge of the pattern.

The final and always the trickiest part of the moulding operation is the clear





withdrawal of the pattern. The twin sketches at 18 show, in sequence, the actual rapping. The expert moulder transmits a rapid vibration to the bar held vertically in the pattern by means of the striker moving from side to side across it. The action is continued in all directions until the pattern appears quite visibly loose.

The hook is screwed into the place in the pattern vacated by the rapping bar and the pattern is lifted out.

Hopefully the pattern will have left the sand in a clean draw but this is the stage at which the cavity can be examined for faults. Careful modelling will often allow damaged parts of the mould to be replaced and made good. A little extra water carefully applied with the soft brush can help to strengthen doubtful places. Near to the joint line of the mould it can do little harm as, when it evaporates, it can escape freely. Water to the deeper parts of the mould should be applied, if at all, very sparingly indeed. Small specks of sand will leave tiny hollows in the surface of the casting and, as these will appear

on the upper parts where they will be seen, the camel hair brush again comes in useful. Moistened, the sand particles will adhere to it and can be lifted out. Small hollows in the mould can better be tolerated as these will leave extra metal which can be removed later.

When metal is run into a raw mould it tends to solidify with a rough skin, reproducing the sand texture of the cavity. It is not possible to avoid this 'as cast' appearance completely but to improve the surface finish the interior of the mould can be treated. The common treatment well known in the foundry is the dusting with blacking or plumbago. A calico bag or a sieve can be employed satisfactorily and a small pair of bellows will help in the distribution of the dust. The most usual blacking to be used is, in fact, graphite in one form or another. As well as improving the finish of the casting and preventing what is known as metal penetration of the sand, the plumbago (graphite) also tends to aid the flow of the metal.

Blacking can be used for a mould intended to receive light alloy, brasses or iron.

But for light alloy particularly, because of its low melting point, an alternative dressing can be talc or French chalk.

For special purposes, foundry suppliers

also market spirit-based mould dressings which can be sprayed on the interior of the mould and, afterwards, fired to produce a shallow skin drying.

CHAPTER 2

Patterns

Almost without question the most important section of any foundry is the pattern-making department. The facility for melting the metal in controlled quality and the mould-making expertise are all quite futile if the pattern making is suspect. This is just as true as regards the backyard foundry as it is in the industrial field.

It is also true, particularly when the project is expected to be a 'one off' job, that the amateur foundryman feels himself reluctant to 'waste time' on a carefully made pattern. The expression 'one off' is usually a misnomer in any case. It is not acting particularly sensibly to cast only one piece, even when only one casting is required for the job in hand. An extra casting is always a form of insurance against possible future damage or errors in machining.

But the real fallacy is behind the idea that the pattern is made to be scrapped after a single use, therefore a roughly made pattern requiring the minimum of effort will serve the purpose. Fact number one, however, is that the rougher the pattern the more difficult it will be to mould. Fact two: a rough pattern can only produce an even rougher casting!

A quickie, knocked together pattern has often been known to produce a cast-

ing so poor that far more time and effort has had to be wasted subsequently, fettling the casting to some semblance of order, than could possibly have been spent in making a good pattern in the first instance. The casting is usually of a good deal harder material for 'cleaning up' than would have been chosen for the production of a pattern.

For people not already acquainted with the foundry process it is often a matter of mental re-alignment. Someone who is happily accustomed to setting up metal components for the most elaborate machining operation, even from the solid, may well feel completely at a loss when confronted with a drawing and



'a few bits of wood' to shape and fit together. Indeed he may also feel superior to the task! You may well have heard some proud machinist declare, "I don't turn wood on my lathe!" Yet, what harm would it do? Not as much as the furtive bit of grinding he probably does from time to time, you may be sure.

An amateur pattern may never reach the high standard of the professional job so, for his own benefit, it is up to the backyard foundryman to work to the best of his ability. In any case, if there is pride in the finished job, why not in the pattern job?

The soleplate, although really hypothetical, which was used to illustrate the moulding process in the first chapter, may well serve as an example of elementary pattern making. It could also be a valid component in an actual project. It is well within the scope of the backyard foundry.

Of course, it doesn't have to be cast at all. It would be quite possible to machine it from one solid slab of metal. It could be fabricated by bolting or welding the separate pieces together, but each piece would have to be cut to shape first and that, from even the easiest working of metals, would call for a considerable amount of effort. If done by hand, considerable energy, too!

However, the base of a drill stand usually is cast as are other components of the same machine. Even if the backyard foundryman's facilities run only to low melting point light alloy, the result can compare favourably with many a production machine sold today for light work – and at high price!

You will probably think of a foundry pattern in terms of wood. From the point of view of convenience and availability as a material it is difficult for it to be superseded. In terms of patterns for

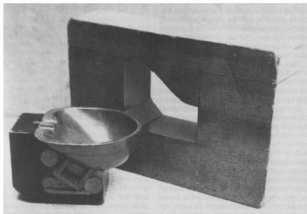
machine parts it is virtually unassailable. In spite of modern synthetic products, industry still continues to use it for original patterns although copy patterns cast from the original wooden ones may well be passed on to the production foundry later.

There seems, therefore, to be little sound reason for the amateur to search around for an alternative material for his patterns. Thus, in this case, wood is chosen for the pattern of the drill stand base.

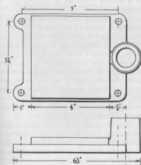
Various woods are suitable. Common wood in the pattern shop is yellow pine, but there are plenty of alternatives – a great deal depends upon availability. Obechi is pleasant to work with and has no very pronounced grain. A good finish can be imparted to cedar and, although frowned upon because it is liable to separate in its laminations in damp conditions, plywood. It is useful in the amateur workshop because of its availability in a great variety of uniform thicknesses and, of course, it can often be obtained in just the right gauge for the section of pattern required.

Very hard woods, although at first quite a logical choice, are not really necessary and may, in fact, be found difficult to work. There is no need to add to the problems – the woods already mentioned and any similar woods will stand up to the conditions of moulding quite well, bearing in mind always that the pattern is to be protected with paint.

The pattern begins with a drawing. Sketch 20 is a typical working drawing for the base of a light drill such as is being described, and, for most practical purposes, measurements may be taken from this and applied directly to the making of the pattern. However, there are two points in particular in which the pattern will differ from the drawing. First

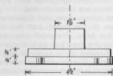


Professionally made pattern of miniature dredger bucket in obechi. The large block is the corebox



(20)

SOLE PLATE
FOR LIGHT DRILL



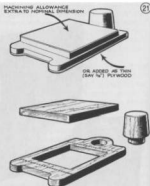
and foremost is the matter of machining allowance. Apart from the drilling of the holes for the holding down bolts, this casting will be machined on the base, the upper side and the top of the pillar boss. This latter will also be bored through to take the pillar.

The measurements of the drawing will, therefore, be increased as shown in sketch 21. One sixteenth of an inch will be added to the thickness of the base, the table and the height of the column.

The second point is the allowance for contraction. According to the metal poured, shrinkage will occur in all directions in the casting at the rate of approximately $\frac{1}{16}$ inch to the foot for iron or $\frac{1}{8}$ inch to the foot for aluminium alloy. This extra metal can be allowed for in the new drawing. In a pattern shop, an appropriate contraction scale, a shrink rule, would be used for this purpose, but for the size of pattern usually encountered by the home worker an allowance close enough for practical purposes by the addition of a fraction of an inch pro ratum should be satisfactory. In any case, shrink rules are not widely stocked by departmental stores and DIY merchants and they may be difficult to come by.

Special attention must be paid to the shrinkage factor in the case of a pattern where a number of centres must be located at an accurate distance apart. The matter becomes more important still when the pattern being made is one from which subsequent metal patterns are to be cast in, say, light alloy. Here a double shrinkage has to be allowed.

This pattern, then, will consist of two pieces of flat wood and one turned wooden boss. Plywood may well be chosen for the flats and, if marine or resin bonded ply is available, so much the better. The full plan plus contraction allowance is drawn on one piece of wood



and the square table on another. The pillar centre is marked out on the wood which is to form the base and a hole is bored through at this point for subsequent location of the round boss. For the rest it is simply a matter of cutting out following the outline.

If a jig-saw or band-saw is available for this work some advantage can be gained by setting the saw table over to cut a small draught angle at the same time. A small deviation from the simple pattern shown in the first chapter is the hollow underside to the table. This is a normal procedure, in keeping with everyday practice, and does not complicate the moulding in the least as long as the cut-out which forms the recess has its own internal draught angle.

The 'draught angle' is the angular clearance imparted to all patterns to enable them to be drawn from the sand. It may be likened to the sloping sides of a child's beach bucket!

Five degrees of slope on the sides of a pattern will be more than adequate for most purposes. On very shallow patterns the draught can be nearly eliminated, but it may be wise to exaggerate the draught on deeper sections e.g. the drill pillar boss on the present pattern. A 'negative' draught, if it is possible to describe it as such, must be avoided and it may well be advisable to check the pattern at all stages of production to ensure that there are no built-in undercuts. An experienced moulder would have no problem with drawing the deeper sections of a pattern but a little extra draught would make allowances for the backyard foundryman's involuntary 'dither' towards the end of the draw.

But on the underside of the present pattern the hollow base to the soleplate presents another problem. The draw here would take place without prior rapping as it occurs at the time when the two parts of the mould are first separated. With such a shallow recess and plenty of angle allowed the pattern should leave the mould cleanly enough. However, if

difficulty is encountered, a certain amount of rapping can be accomplished while the mould is still closed. Either the pointed rapping bar can be inserted into the pattern through the sand in roughly the location it is known to occupy or alternatively the bar can be placed on the pattern in the correct position for rapping and the sand rammed up around it. It is removed for completing the mould, of course, but the point at which it has to be inserted can easily be found when the time comes. The foregoing is more particularly applicable when a mould containing a double-sided pattern with deep contours is being separated.

Patterns to accept loose cores

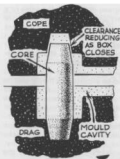
It has been seen how some metal has been saved and the casting rendered lighter by making the underside of the foot hollow. Normally, however, the heavy cylindrical section would also be lightened by means of a 'core'. Simply, this is a solid cylinder of dried sand (see Chapter 4) which is fitted into the mould so that the metal flows round it. After the metal has cooled, this sand is removed and leaves a clean hole in the casting, but the location of the core must be determined at the pattern making stage.

Thus the forming of a cored hole calls for additional work on the pattern as well as making a 'box' to produce the sand core. As regards the pattern itself this means the addition of 'prints' to the top and bottom of the section to be cored. Now, as well as its own imprint, the pattern will leave sockets in the sand that will positively locate the inserted core.

Looking at the example shown, a convenient way to form the print at the top is to turn the extra piece integral with the boss itself. But in order to preserve the flat base to the pattern for convenience in moulding, the print on the underside is



Motor casing cast in two parts plus the foot. Light alloy.



(22)

best made as a loose part.

While the woodwork is set up for turning the boss and its upper print a small hole should be bored right through the

centre: $\frac{1}{8}$ " would be sufficient diameter for this. The lower print is turned and finished quite separately from the pattern and is fitted with a centre pin or dowel,



PATTERN FOR ELECTRIC MOTOR END-PLATE WHICH LEAVES ITS OWN CORE

(23)



LEAVE OUT THE DIMPLE



A FLAT BOSS IS BETTER FOR MARKING OUT

perhaps of brass, to match the hole. This allows the print to be located on the pattern after the first half of the mould is rammed up and the drag is turned over. Prints are given a generous draught angle to make sure there is plenty of clearance for the sand core when the box is being closed prior to pouring, as at this time the interior of the mould is out of sight to the moulder, sketch 22.

The techniques of pattern making and core making are virtually inseparable. 'Cores', as far as the moulder is concerned, will be seen then to be divided broadly into two categories. The first, like the hollow foot of the present casting, is left in the moulding sand by a cavity in the pattern itself. It is often remarkable how deep and how complex these integral cores can be made with success. This is perhaps one field where the backyard foundryman can legitimately economise in the production of a pattern by designing his casting in such a way that the need for a separate core is avoided. Sketch 23 is such an example.

The second kind is the loose core which, as already described, is moulded quite apart from the main pattern and is inserted in the mould cavity after the pattern has been withdrawn. A simple cylinder of sand leaves a straight-through hole in the casting, but the core may, equally well, be in itself more complex in shape than the pattern it is designed to accompany. In some instances the core may be built up from more than one part and other cores may be arranged to fit to prints in the main core.

Double-sided patterns

Of course, the present pattern calls for no such elaboration, and except for the single removable core print and the recessed underside it can fairly be regarded as a single-sided pattern. More complication

is involved when the pattern has similar, or nearly similar, contours on both sides.

For the machine part illustrated in sketch 24 it will be seen at once that a double-sided pattern is needed. This pattern will carry prints for three dried cores as well as leaving two small, rectangular greensand cores in the mould.

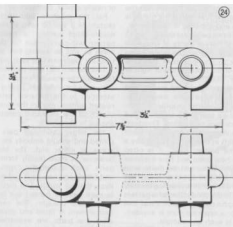
This pattern can also be made exactly following the drawing except for the due allowance for shrinkage, paying particular attention to the distance between the related centres, and for the core prints. A sketch of the exploded construction is shown in sketch 25.

The large, cylindrical part is easily turned and should embody its own core prints at either end. The main body, however, is more readily formed in two parts, each of half the depth required, and fitted together, back-to-back, to produce the full width. The central recess in each case is fretted out leaving the appropriate draught. The central web (not shown) is fitted and glued in place after the parts are assembled. Alternatively – and it is only a matter of choice – the main body can be made from a central section equal to the thickness of the web, sandwiched between two shallower side panels.

Additional material as machining allowance is provided by fitting thin plywood discs on the four faces of the round bushes. The centres of these bushes are accurately drilled through, again about $\frac{1}{8}$ " , to provide a register and all parts, including the four tapered prints, are impaled together on a dowel and glued.

PVA adhesive has superseded animal glue in the modern workshop and there will also be places where modern fillers can be used to advantage: plastic wood, Brummer stopper, Polycell filler and even epoxy resin, to mention but a few.

As patterns become more complicated



and carry deeper sections the importance of finish cannot be over-emphasised. With a double-sided pattern of this kind there is also the question of the line of separation of the two parts of the mould.

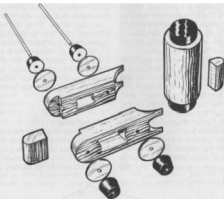
Ideally the division in the mould should lie through the centre line of the pattern with equal contour on both sides. There are several means by which this can be achieved with a greater or lesser degree of accuracy.

The pattern cannot be laid conveniently flat on the board as before, of course. The moulder has first to prepare himself a sand bed to lay the pattern in. For this he takes the box half with the pins uppermost and packs it with sand quite firmly – not, perhaps, quite as firm as ramming

– and smooths off the top to leave a perfectly flat surface.

He now makes a judgement as to the best placing of the pattern with the usual regard for the position of the sprue. Here he excavates in the flat sand an approximate hollow, testing with the pattern from time to time, until he is satisfied that the pattern will sit nicely in the sand to its approximate centre line. The sand around the pattern is now made good and firm with the small trowel and the surplus sand brushed or blown away.

From this point onwards he treats his pattern as a single-sided one and, having dusted his 'oddside' with parting powder he proceeds to ram up the drag box in the usual way. The adhesion of the rammed



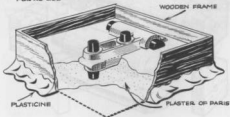
sand should overcome that of the more loosely packed sand of the oddside and when the two are separated the pattern should remain embedded in the drag. If there is the slightest doubt of this the pair of boxes should be inverted together

for the separation. The oddside is then emptied out and the box now used to ram the cope.

The method of moulding a double-sided pattern just described tends to become tedious if a number of castings

MAKING A PLASTER ODDSIDE FOR RE-USE

(26)



of the same pattern are required. If that is the case a more permanent oddside can be made which can be used over and over again in conjunction with the pattern. This is a matter of making a plaster impression of one side of the pattern.

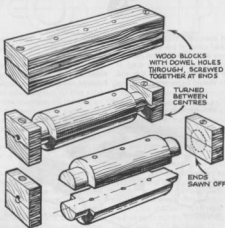
A shallow wooden frame is first prepared on a flat surface of dimensions sufficient to allow the pattern to be laid inside with half an inch or so clearance all round. The frame can be sealed with plasticine at the bottom and oiled on the inside to allow for easy stripping. The pattern is also oiled. Plaster of Paris is now poured into the frame to an adequate depth and the pattern immediately half submerged in the plaster, down to the desired parting line. When the plaster has set the pattern is removed and the

upper surface of the plaster fettled to reasonable flatness, sketch 26.

In use when it is dry the plaster oddside, with the pattern loosened, is covered by a half flask and rammed up in the usual way. When this is turned over the pattern should now be embedded in the sand where it is dusted with parting powder and the sprue stick inserted, ready for the second half of the mould to be completed.

Split patterns

For castings of pronounced contours on both sides of the parting line the moulding operation can be simplified much further by the use of a split pattern. The word 'split', however, can be very misleading.



In fact, it is seldom practical actually to split the pattern in the literal sense – it is in effect a 'two-part' pattern.

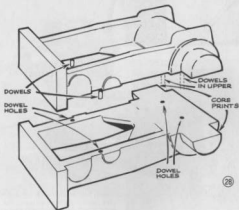
In making a split pattern the two parts should be separate right from the commencement, each located to the other by means of dowels. For example, the blank for turning a cylindrical section, which is to lie horizontally in the mould, should be prepared as two separate pieces of wood of rectangular section screwed and doweled together. They are turned as one, as shown in sketch 27. Metal workers will probably prefer to chuck one end and centre the other. The rest of a divided pattern would be built up similarly, the remaining details being added as for the solid pattern. Finally, permanent dowels, utilising some of the holes made in the preparation of the pattern, would be fitted in appropriate

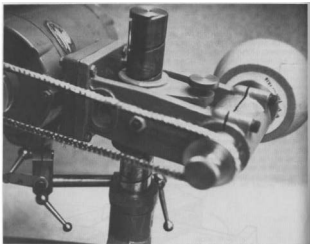
places to locate the two halves.

The additional effort required for this at the pattern-making stage is very slight but the advantage gained when it comes to moulding is very considerable.

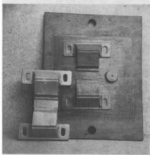
One half of the pattern will have the locating pins protruding from the flat side. The other will be plain. It is the plain half which is laid down flat on the moulding board at the start of the operation. The part of the pattern with the dowels is fitted in place after the first half-mould has been rammed up and inverted. The work carries on then as it would for the one-sided pattern, dusting with parting powder, fitting a sprue stick and so on, but when the mould is split, one half of the pattern remains to be rapped from each box.

The permanent dowels can conveniently be made of short lengths of brass

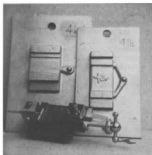




Headstock for the "Quorn". Two castings in iron and a light alloy foot to suit the motor.

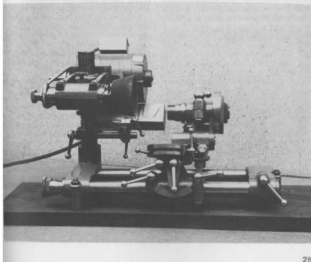


Motor foot moulded from a plate pattern. A very useful pattern because the foot suits most fractional horsepower motors.



Two plates to mould this cut-off slide and saddle for a small turret lathe. Castings in iron with a light-alloy extension.

The complete 'Quorn' tool grinder from the backyard foundry. Castings in iron with rotating table in bronze.



rod, $\frac{1}{8}$ " diameter, embedded in the pattern. The holes to receive them which have already been drilled in the wood will be adequate for home foundry purposes, but they must be free enough to allow the box to be parted without dragging either pattern half from the sand. If a good deal of use is anticipated the holes may be conveniently protected by small brass plates let into the wood and screwed there.

Pattern finish

Before it is used a wooden pattern needs a protective coating against the erosion of the damp sand during moulding. The traditional material in the pattern shop is shellac, which can be applied by brush and cut down between coats until a very high finish is obtained. Shellac is useful because it dries quickly and a succession

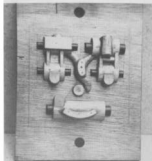
of coats can be applied without too long a wait in between. Core prints are often painted with lamp black before the shellac so that they can be readily identified by the moulder.

Modern paints are less expensive than shellac and they allow plenty of scope for experiment. From the point of view of rapid drying and hardness, cellulose finishes have a great deal to commend them.

A good basis to any pattern painting is a couple of coats of sanding sealer, which can be obtained in small enough quantities from model shops. The most important surfaces for attention are the vertical ones – these should be checked for draught with a square and, within reason, all irregularities eliminated with fine sandpaper as the painting proceeds.

Cellulose spraying facilities are readily available through the medium of the aerosol can. Obviously a superb painted finish can be applied to a wooden pattern in this way, but one point which deserves attention is a possible paint build-up on the upper edges of the pattern which if care is not taken, may destroy the otherwise adequate draught angle.

When finishing off plain round bosses on a pattern there is often a temptation to make a small indent or 'pip' in the pattern where, clearly, the centre of the casting is expected to occur. It may seem a good idea but it should be resisted. It could, in fact, make the task of accurately locating the centre more difficult. The centring drill, when presented to the casting, will have the tendency always to run off into the pip, which may not be the accurate centre required. It will be found much easier to do accurate marking out on a plain, smooth surface.



One of the multiple pattern plates for the 'Quorn'.

CHAPTER 3

Plate Patterns

With the patterns and moulding methods so far described it has always been necessary for a certain amount of careful hand work for the completion of the mould. This reference is, of course, to the cutting of the ingates — this may sometimes mean inadvertent damage to the mould cavity which, for repair, calls for further handwork. A fresh location for the ingate is made each time a new mould is prepared and it is always liable to be a random matter, both from the point of view of size and position. All this manipulation can add up to a disturbance of the sand which tends to spoil a good mould.

However, difficulties of this kind can be largely overcome by the adoption of pattern-making methods perhaps more likely to be associated with the production foundry. This is by making what is known as a 'plate pattern' instead of the more usual loose variety, solid or split.

The basis of the plate pattern, in so far as it concerns the backyard foundryman, is a piece of plywood, resin bonded for preference, of a thickness of, say, 10 mm or $\frac{3}{8}$ ". The thickness of material chosen really depends on the size of the moulding box to be employed, as it requires to be quite stiff. The size to which the plywood

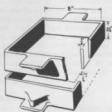
board is cut is large enough to cover the complete box and its register pins with a respectable margin all round. Holes are drilled in the board at opposite ends to fit exactly over the box pins. Prior to commencing a pattern-making session have a small stack of boards cut to size and drilled ready, to draw on as needed.

In this respect it would be a wise strategy in the first place to have all your moulding boxes to the same dimensions or, at least, to the same pin centres.

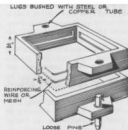
For the serious amateur the best advice would be to obtain two or three manufactured moulding boxes at the outset. Of course, if well made steel flasks can be fabricated at home, the cost would be much less and wooden boxes are also valid. For successful use with pattern plates, however, special attention should be paid to the locating pins, which should be substantial and rigidly fixed on brackets to the outside of the boxes.

All other things being equal, the only possible disadvantage to the wooden moulding box, providing it is stoutly made, is that a much more comfortable distance has to be allowed between the extremities of the pattern and the sides of the box. The clearance has to be quite generous when iron is to be cast if scorch-

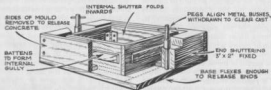
(28)



PATTERN FOR CAST IRON FLASK
SHOWING UNDERSIDE OF LUGS



CONCRETE MOULDING BOX



WOODEN MOULD TO CAST CONCRETE FLASK

ing is to be avoided.

A home-made moulding box can be fabricated from strip steel $2\frac{1}{2}$ " or 3" wide according to the depth of flask required. A gauge of steel of roughly $\frac{1}{8}$ " is adequate for a box up to 10" square because it should be further reinforced on the inside with more strip steel following the internal contour. Two such strips are placed top and bottom of each box part, leaving a gully an inch wide in the middle. It looks like an acceptable alternative to place one such strip half-way down the inside but this is not such a happy solution as it may seem. Such a

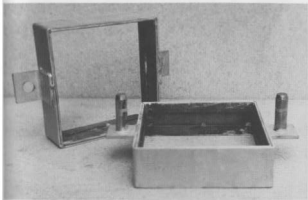
strip would interfere with the comfortable ramming and, at the same time, it does leave rather a thin edge to the flask of only $\frac{1}{8}$ ".

Lugs for the home-made box are short pieces of angle-iron $\frac{1}{4}$ " or $\frac{3}{8}$ " thick, and handles, if they are fitted, are bent from $\frac{1}{2}$ " diameter rod. When a flask is likely to be weighty when loaded it is well to have handles situated in such a position that a couple of fingers can press downwards against the lower handle while other fingers lift against the upper. With pattern plates a vertical lift is essential and there seems always to be a tendency

for the pins to jam unless they can be eased truly upwards.

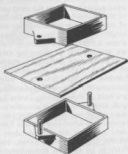
If flasks are purchased, some consideration should be given to the size of them relative to ease of handling. That is to say, the matter of weight. Boxes with an internal dimension of only a foot square by 3" deep can weigh up to a hundredweight when rammed up with sand. That makes the job of moving them about quite difficult for one person, who may not normally be accustomed to that kind of lifting. A recommended size of box is 8" x 8" x 2 1/2" weighing from 40 to 50 lb when full and capable of accommodating all but the most ambitious castings likely to be undertaken. If this seems small, you are reminded that the size of casting is governed by the quantity of metal melted as well as the size of the pattern and the flask.

The ideal flask takes the form of two rectangular, deep frames rolled from sheet steel of about 1/4" thick. Smooth, vertical sides would not retain the sand very well so an internal key is provided in the form of one or more gutters rolled into the length of steel before the rectangular shape is formed. The seams of the boxes are welded and at opposing sides the lugs or brackets, which carry the register pins and probably incorporate lifting handles, are also welded or otherwise permanently secured. Sometimes pins are held in their sockets in the lugs by grub screws, making it possible to withdraw or replace them, perhaps with extended pins when two or more flasks are used together for a particularly deep mould. Even on small boxes, pins are likely to be as large and substantial as 1/4" diameter.

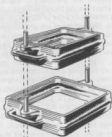


Home-made steel moulding box by Eric Smith.

30

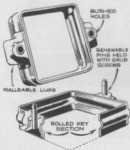


THE BASIC PATTERN PLATE

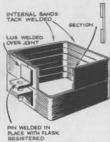


DIFFERENT SIZE BOXES WITH THE SAME PIN CENTRES

31



COMMERCIAL STEEL MOULDING BOX



HOME MADE STEEL FLASK

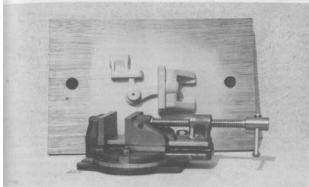
As commercial moulding boxes are expensive, it may well benefit the beginner to look around for more economical ways of procuring them. One possible way, which might be worth considering, would be to prepare a wooden pattern of a box half including lugs and have this reproduced at a local foundry. One well designed pattern could reproduce all the flasks needed. The 'as cast' interior would provide adequate natural keying for a small flask.

Concrete is also used commercially for moulding boxes and small flasks of this material are not outside the scope of the home worker.

With the plate pattern the box pins guarantee the register of the two halves of the mould, always providing, of course, that the top has been replaced the correct way round. But another important

function is to control the withdrawal of the pattern. The latter is particularly important where castings with a deep contour are attempted; even more so with those which leave their own core.

Perhaps the most important advantage of the plate pattern over the separate pattern is the ease with which the rapping can be accomplished while the box is still closed. The vibration that loosens the pattern is imparted by the use of a wooden mallet applied freely round the edge of the board where it projects from the sides of the box. This, of course, has the effect of freeing the pattern in both halves of the box at the same time. The mallet need not be spared. When the mould is split the pins guide the upper part clear of the pattern and, in the same way, they guide the complete removal of the pattern from the mould.

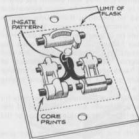


Machine vices are expensive. Moving jaw and nut from this pattern plate cast in iron to repair this vice.

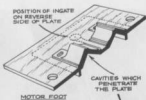


TAPPING ALL ROUND
THE PLATE WITH A
Mallet

MULTIPLE PATTERN PLATE



THIS IS THE UNDERSIDE OF THE
PATTERN



MOTOR FOOT

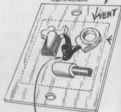
CAVITIES WHICH
PENETRATE
THE PLATE



LATHE SADDLE

WITH FELT PEN
MARK POSITION WHERE
VENT IS WANTED

ALSO SERVES AS A
REMARKER



THIS BRANCH JOINS THE
INGATE PROPER ON
THE REVERSE SIDE
OF THE PLATE

Another important advantage that the plate pattern has over the loose type is that the plate carries, in addition to the pattern proper, extra patterns to form the ingate and sprue cup. On the plate the pouring sprue is located in exactly the same place every time by means of a brass dowel on the end of the sprue stick.

Where patterns are relatively small several can be accommodated on one board, all of them permanently linked to the sprue by a branched ingate pattern. The position of the feed to each mould can be carefully selected in advance. The best location is chosen guided by the experience of the moulder while, of course, the distribution of the patterns is arranged with this in mind.

But possibly it is in the production of the pattern itself that the main advantage of the plate type becomes evident. It will at once become apparent that, where the pattern is likely to be a fairly complicated shape, every advantage will be gained by marking it out and then building it up on the plywood board.

First, the board is placed in position on the pegs of the appropriate box to be used in the moulding and the inner limits of the box clearly marked on it. Thus there will be no risk of the finished pattern being too close to, or overlapping, the box sides. Where steel moulding boxes are to be used the patterns can, and frequently are due to the limited space available, be brought within a quarter of an inch of the box sides. An inch margin might be nearer the mark when using a wooden flask for iron. Always consider the melting point of the metal when laying out the patterns.

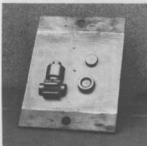
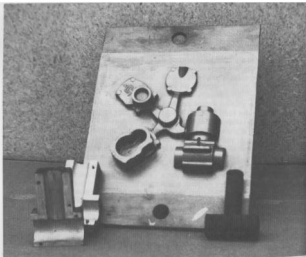
The best position on the plate is selected, too, for the pattern with due regard for the siting of the sprue and ingate. The main points of the drawing are transferred to the plate and the im-

portant centres and other features are clearly marked. Sometimes as the pieces of the pattern are made these can be built up on the board, although it is well to commence by working on one side of the plate only. Cylindrical sections turned in two parts which have been dowelled together, are separated and their relative position on either side of the board determined by drilling through the self-same dowel holes. Other symmetrical details will have an equal thickness on either side, again located by dowels. It will be noted from this that, with reasonable care at this stage, a mis-register of the two parts of the mould and even a bad 'flash' becomes almost impossible.

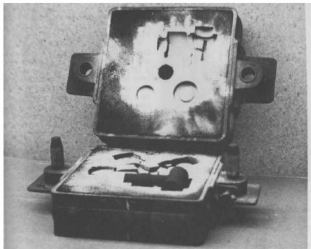
It will be seen that the thickness of the board itself can be ignored. Straight-through pierced sections of the pattern are no problem — in that case both sides of the pattern are penetrated equally to the surface of the board. Since the rapping of the pattern will be just as thorough at all points on its surface there is not the same need as with a loose pattern to allow extra draught on the inside of such cores.

Extra depth to a hollow part on one side only of the pattern can be taken care of simply by fretting out the extra from the plate itself before the pattern is assembled. To this degree, of course, the depth available is governed by the thickness of the plywood being used for the plate. The matter can be considered at the outset and, within reason, an appropriate thickness of wood chosen. This penetration of the plate must be given draught also and this must conform to the pattern on the side of the plate to which it relates.

More depth still can only be dealt with by further penetration of the back of the pattern, always remembering that now, the thickness of the plate does have to



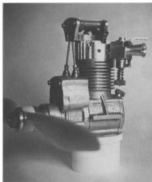
Both sides of the plate for a 10 cc ohv engine with core and corebox.



The mould prepared for the 10 cc engine.



The spray of castings for the engine, and...



The finished engine.

be taken into consideration and allowed for in so far as it concerns the depth of the hollow.

Weight of casting

It also makes sound sense to mark on each pattern plate – or indeed on each loose pattern also, for that matter – the weight of metal needed to pour it. After the first pour, of course, the total weight of metal required to cast pattern, ingate and sprue will be known simply by hanging the casting on a spring balance. A note should certainly be made of this. Meanwhile it is possible to arrive at a close approximation by weighing the pattern complete with plate, weighing a spare plate, and subtracting one from the other. If a scrap runner of similar size is available, add the weight of that. Until a finished casting from any particular pattern has been weighed, however, always err on the generous side. If in

doubt at all, always fill the crucible and then you will spare yourself the chagrin of realising too late that you could have had enough metal.

Various woods have different densities. Oak, for example, weighs a little over one and a half times the weight of pine. It is, perhaps, unlikely that oak will be used for a pattern. It has rather too pronounced a grain to allow it to be finished to a really smooth surface. Mahogany might be used, however, and that can be regarded as having a very similar density. Pine, on the other hand, is probably in the same group as the lighter woods such as obechi and cedar, etc.

As a guide only, if the pattern is of pine or a similar wood: for an iron casting multiply the weight of the pattern by 13.6; for cuprous alloy multiply the weight of the pattern by 14.7; for light alloys multiply the weight of the pattern by 4.7.

If there are core prints on the pattern there are further complications to the calculations, as neither the print nor the volume of the core will be included in the weight of the finished casting. Therefore the tendency will be for ample metal to be melted in any case – which is a good thing!

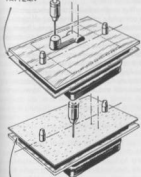
The turn-over plate, or two for the price of one

The use of the plate type pattern may often allow certain economies in the making of the pattern itself. Where a casting will be symmetrical, above and below the parting line – a wheel is often a good example of this – a full casting may be perfectly reproduced from a half-pattern only mounted centrally on one side. Providing the pattern is accurately located dead in line with the centre-line of the box pins, the plate can be turned over after moulding the first half box and the

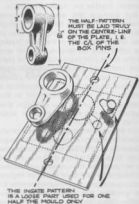


A TWO-PART MOULD
FROM ONLY HALF
A PATTERN

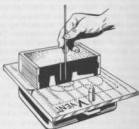
TEMPLATE UNDER PATTERN PLATE
FOR LOCATING FIRST HALF OF
PATTERN



TEMPLATE ABOVE PATTERN PLATE
AND REVERSED FOR LOCATING SECOND
HALF OF PATTERN THROUGH
ORIGINAL DRAWINGS



THE INGATE PATTERN
IS A LOOSE PART USED FOR ONE
HALF THE MOULD ONLY



VENTING A DEEP CORE FOLLOWING
THE INDICATIONS ON THE MARGIN
OF THE PATTERN

second half thus moulded from the same pattern. Ingates are made detachable.

But perhaps the economy is most noticeable when two halves of a single split pattern can be mounted, side by side, on the same side of the plate (leaving the other side completely vacant) and, by the same process of turning the plate over, two castings can be produced from the same pattern. In this case the pattern may well be completely asymmetrical in contour. The only requirement is that there is room for the two castings, their ingates and the down runner or sprue within the limits of the box.

To ensure the accurate register of the halves of the two castings the simple expedient is to utilise a second plywood plate. One-eighth inch or 3 mm ply will be adequate for this job and it may well be used over and over again to register subsequent patterns. Its dimensions are the same as the regular pattern plates and it carries the holes for the box pins.

The divided pattern as made will carry dowels to locate the two halves together. It is by passing a drill through these dowel holes that the parts of the pattern can be effectively lined up. The half flask with the pins is the key to the process. First the thin template followed by the plate proper are placed on the pins. The middle of the plate is found as a guide line drawn from pin to pin. The first half

of the pattern is positioned to one side of this line. It doesn't even have to be squared up, though it probably looks better if it is. Held down firmly in the place selected, a drill of the same size as the dowel holes is passed through at least two of them and continued through both pattern plate and template.

Clearly now, if the template is brought to the top and reversed side for side over the pattern plate, holes drilled through the latter, through the template holes, will permit the registering perfectly of the second half of the pattern through its own dowel holes.

The sprue is arranged with reasonable accuracy midway between the two parts of the pattern at a point where the feed will be deemed satisfactory and one ingate pattern will be fitted. When the board is inverted during the moulding process the ingate will be duplicated so that both moulds will be fed to the same point of entry.

The single-sided pattern plate producing a complete casting from a half pattern is common enough in commercial foundries. The 'two for the price of one' technique, however, may not be encountered in industry. Nevertheless, as will be seen from the several examples described in the following pages, it would appear to be absolutely functional and have a good deal of practical value to the home foundryman.

CHAPTER 4

Cores, Core Boxes and Core Making

The sand core in its most elementary form, as dealt with briefly in Chapter 2, is that which is simply left in the mould in greensand by a hollow in the pattern itself. That kind of pattern will be said to 'leave its own core' which, in turn, will form a hollow in the casting. This may be shallow or deep, simple or complex, but the deeper it gets in relation to its bulk the more attention it requires at the moulding stage.

To begin with it may call for particular attention in the matter of venting. Greensand cores need to be well penetrated by the venting rod, perhaps in several places according to the size and depth of the core. The venting rod can be pushed right through the sand until it comes into contact with the pattern. It can then be plunged up and down a few times to cause a plug of sand to be formed in the bottom of the vent to prevent metal penetration. The rod should be blunt at the end for this.

The moulder then has to decide if such a core is going to be sufficiently robust to withstand, first, the inversion of the mould when that occurs, and second, the erosion of the incoming metal. Strength of a core can be much improved by the use of nails or wire as reinforcement

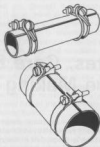
when the mould is rammed up. The core is given a lining of sand to begin with and the wire etc. embedded in this and held with the fingers while further sand is added and pressed in. Some care has to be taken not to dislodge the reinforcement with the venting rod.

Within its obvious limits such a core can be remarkably successful and, where pattern making must be kept simple, it can be exploited to quite a considerable extent.

But where such an arrangement does not meet the requirements of the casting and where internal undercuts or long bores are encountered, the loose core method has to be adopted. Cores, of course, although they represent a greater expenditure of effort, do have the redeeming feature that they can also mean a large saving in metal. This is a matter of importance where melting facilities are limited and only a comparatively small quantity can be melted at a time.

If a separate core is to be used arrangements for it have to be included in the design stage for it to be located in the mould. As already has been shown, additional bosses of cylindrical or other shape have to be arranged to appear on the pattern in direct relationship to the

BENT WIRE OR NAILS EMBEDDED IN THE SAND OF DEEP HOLLOWS AT THE TIME OF RAMMING



USEFUL COREBOXES FROM SPLIT TUBES

position and direction in which the cores are intended to run. Each print leaves its own impression in the mould so that, after the pattern has been removed, the appropriate core can be fitted within the mould in correct alignment and without danger of moving. But the separate core thus described is produced in quite a different way from the ordinary moulding process and, so that it can be conveniently handled, it has to be dried out thoroughly in an oven before it can be inserted in the mould.

The drying out or baking of cores serves a double purpose. Its main function is to exclude all moisture. The ordinary dampness of a greensand mould can be tolerated where the core is moulded from the pattern because there is a large area of contact between the base of the core and the mould proper to permit the dissipation of steam and gas; aided by

venting, of course, as aforementioned. The loose core, on the other hand, is likely to be almost completely surrounded by metal when the mould is poured. Provision has to be made for gases to escape freely in the venting, also, of the loose cores, but steam from a damp core under these conditions could only be disastrous.

The baking also renders the core firm enough to be managed and fettled where necessary and of adequate strength to resist the pressure and disturbance of the incoming flow of metal. Cores are likely to be made in advance to be ready for the mould-making session and they can be stored until needed. Extra cores should be provided on each occasion in case some may crack or prove unusable after baking.

Core sand differs from that ordinarily used for moulding in that its 'bond' takes

the form of organic or other material added to it whose purpose is to cause the individual grains of sand to adhere to one another. The bonding material, therefore, must on the one hand provide plasticity to allow the sand in its green state to be satisfactorily moulded to the shape of core required. On the other hand, when it is baked it must set in the form of a strong adhesive linking the grains into an apparent solid, without destroying the permeability of the structure.

The sand used to compound the core material need have no natural bond at all. Silica sand is, perhaps, most widely used for core making. This is provided at the seashore. That from the sandhills, being windblown, is free from particles of shell, but dried and sifted quarry sand will also make good cores. The difference seems to be in the effectiveness of the green bond. Silica sand as prepared for core making tends to be lacking in adhesion, but baked it becomes very hard indeed. Quarry sand will have a good green bond but may tend to be a little crumbly after it has been in the oven. Sometimes the best results will be found with a mixture of both.

Preparation for core making first requires that the sand be mixed or milled together with a drying oil such as boiled linseed oil. This will harden in the oven and give the cores their dry bond. Core-sand mixers are large and heavy machines. A convenient way of achieving a comparable result on a small scale has to be found, and since it is a matter of coating evenly a very large number of sand grains with a very small amount of bonding agent, a mechanical means of some sort has to be found.

Perhaps a portable electric drill, likely to be a part of most home workshop equipment today, as used for paint mixing, provides the best answer. A simple

beater can be formed by bending a hook at the end of a $\frac{1}{4}$ " diameter steel rod, the other end being held in the chuck of the drill.

The linseed oil alone does not permit easy moulding and, to improve the green bond of the core material, various other organic substances are added. Dextrin and molasses, for example, and even a paste made from flour or starch mixed in the proportion of, roughly, equal parts of oil and paste. The object is to render the sand of a plastic consistency to suit the moulder. The proportion of oil and paste together to that of dry sand would be in the region of 2 to 3 per cent. A similar quantity of water can be added to the mix a little at a time until the condition is right, a matter which can best be judged from experience.



SIMPLE BEATER FOR MIXING CORE-SAND

An alternative to some of the traditional materials mentioned, and one which is often readily available and has been used with some success, is a proprietary cellulose wallpaper paste such as Polycell, used in conjunction with the drying oil in the usual way.

The Fordath Engineering Co., (see Appendix for address) is able to supply a ready mixed core 'cream' (Cream No. 444) capable of being combined with the sand by amateur means and cutting out the necessity for experiment. The manufacturers will supply advice on the best way to use their product.

A sand core process much used in industry today, and which is quite adaptable to the small-scale foundry, is that in which the sand is mixed to a green bond consistency with sodium silicate (water glass). This mixture is rammed into the core boxes in the usual way but, before withdrawal, the core is inoculated by means of a hollow needle with CO_2 under pressure from a bottle or capsule. Adapters for Sparklets bulbs are currently marketed by the Powermax firm of model suppliers. After treatment the core hardens immediately and can be turned out at once but, for safety, excess moisture still needs to be removed in an oven.

Alternatively, if the green bond of the sodium silicate core is good enough to allow handling out of the core box, the cores can be baked in the usual way without the use of CO_2 .

The oven drying of cores can be a problem because, although the domestic oven will serve the purpose very well, the very strong odour and the fumes produced from oilsand at between 400 and 500°F. can render the process somewhat objectionable. The second-hand market may provide the best solution in the form of a small table-top type oven installed in workshop or garage. It may even be found convenient to use it in the open air.

Core boxes

To produce cores from the sand so prepared appropriate moulds known as core boxes are made to suit the pattern in question. If the core required is in the form of a straightforward cylinder a copper or plastic tube, slit down its length and held closed by a screw-driven hose clip, probably forms the simplest core box of all. The only requirement is that the tube selected, in internal diameter and length, suits the prints of the pattern. Obviously, the prints in the first instance can be dimensioned with

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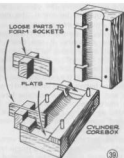


A GROUP OF MINATURE ENGINE CORES OF GREATER OR LESSER COMPLEXITY

the available tube in mind.

Another, and perhaps more traditional core box for moulding a cylindrical core, is easily made by dowelling two rectangular pieces of wood, of equal size, together and boring them through the centre. The bore must be clean and should be sanded to a good finish and sealed with shellac or paint as with the patterns. The two parts are held tightly closed and clamped for ramming the sand and separated to release the core.

An elementary rectangular core can best be made in a frame-type box. The frame is made in the form of two L-shaped parts held closed for filling; the working surface of the bench or a separate base provides the flat underside to the core. The top is simply trowelled flat and smooth. The frame is a very convenient type of core box and is capable of much adaptation to produce cores in all sorts of irregular shapes other than the pure rectangle.



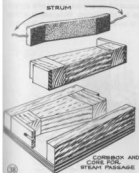
(39)

An alternative to the frame is the "knock-out" type of box which is provided with a draught on the inside that allows it to be rapped and tipped out. A corresponding draught has to be applied to the core print, of course.

Boxes for round cores which are to be inserted vertically in the mould are more difficult to make because the core must be provided with a tapered section at each end to correspond with the tapered prints in the mould. Perhaps the most satisfactory solution to this problem is to make the parallel portion of the box as before and to make and fit the parts carrying the internal tapers separately. If for any reason a core must be prevented from rotation it is usual to provide it with flats at the ends to register with flats on the prints.

Core vents

The matter of venting has been referred to already as regards the kind of core left by the pattern. It is of no less importance, however, when dealing with baked cores



(38)

and the more closely the core is going to be surrounded by metal, the more thorough must be its venting.

As a rule, a simple cylindrical core offers few problems. It can easily be dealt with by piercing it from end to end through the box with a thin rod. Where cores are laid at the joint line of the mould the vents in the core connect with the division between the upper and lower parts and the gases can escape freely. Even more freedom of escape can be provided by scoring a shallow groove in the sand from the position of the core-print to the edge of the flask.

A simple rectangular core can be vented similarly. Where it is made in a frame-type core box small holes can be provided at points on the frame corresponding to the core prints, to permit the insertion and withdrawal of the venting rod.

Cores of a more complicated shape have sometimes to be dealt with by other means, and a reliable method of venting is one which employs waxed string; or indeed, in the case of particularly small cores, waxed thread.

To prepare the string it is sufficient to cut suitable lengths and dip them, one at a time, in paraffin wax. Best results are obtained by coating the string as evenly as possible and it may be necessary to repeat the dipping two or three times to obtain the required build-up.

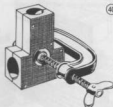
When preparing the core the waxed string is embedded in the sand at the appropriate position with half an inch or so projecting from the ends of the core. As with the rod venting, it may be found convenient to provide holes or slots in the ends of the core box to permit the string to be laid centrally. The rammed cores with their string are then turned out and baked in the usual way. The wax is thus melted out and volatilised and, when the core is cool, it should be pos-

sible to withdraw the string quite freely.

Any disturbance in the mould at the time of pouring will probably result in an unsound casting. A damp or improperly vented core will cause the mould to 'blow' and the evidence of this will usually be visible in the down runner as bubbling or agitation. In really bad cases metal will be ejected from the mould by the built-up pressure of gas and put the foundryman at risk.

There is considerable outward pressure from the sand when a core is being rammed and this increases even further when the venting rod is inserted. The split-tube type of core box looks after itself when the hose clips are tightened to bring the tube to its nominal diameter. The box type of core box, usually two parts located by dowels, can probably be best retained by a small G clamp. Frame-type boxes for flat or rectangular cores are perhaps best fitted within a second frame — a base with sides — where they are held firmly while the sand is pressed in, strickled flat and vented.

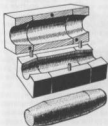
Various types of core boxes of a simple nature are illustrated. They are of a kind likely to be encountered in a home foundry.



A SMALL CLAMP USED TO HOLD THE PARTS OF A CORE BOX TOGETHER DURING RAMMING

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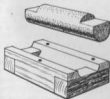
41



CORES WITH TAPERED PRINTS
ARE LOCATED VERTICALLY
FROM DRAG TO COPE

Sketch 41. This is the form of core box used to produce cores with tapered ends. It has been shown how a pronounced draught is given to a core print which is subject to a perpendicular draw. The tapered end to the core ensures firm and vertical alignment so that the upper part of the mould can be lowered into position with reasonable certainty that it will register without mishap.

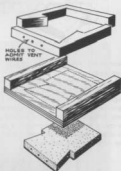
42



FLATS ON THE PRINTS ENSURE
THAT A CORE CAN BE PLACED
ONLY ONE WAY IN RELATION
TO THE MOULD

Sketch 42. This is a sketch which shows how a cylindrical core can be provided with flats to guard against its rotation and, more particularly, ensure that it is inserted in the mould the right way up. It is an arrangement used when such a core carries definite detail which must only appear one way round, such as sockets to receive other cores and so on.

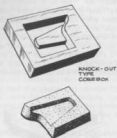
43



A TAIL CORE TO ALLOW OF
OVERHANGING INTO THE MOULD

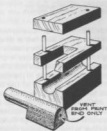
Sketch 43. The flat core produced from this two-part box has a dove-tail print which allows it to be placed overhanging the mould. It requires a corresponding print on the pattern but it leaves a plain, rectangular socket in the casting. One of the L-shaped parts of the box is provided with holes at the print end to permit adequate venting. The core will be all the stronger for wire reinforcing. The plywood base with sides holds the box together while it is being rammed.

44



Sketch 44. Another form of box for a rectangular core which is, virtually, all print! Metal is intended to flow only into the tongue-shaped recess. This box has draught on the inside and the core can simply be tipped out. The lack of arrangements for venting may be noticed. So little metal comes into contact with the core that it was felt the need was not there. It did prove satisfactory.

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Sketch 45. This is a sketch of a three-part box which moulds another kind of 'tail' core. It is an arrangement used when the centre-line of the core does not coincide with the dividing line of the mould. It is also another form of overhung core and the tail print is made as long as the core itself as an insurance against it falling into the mould. For more safety it can also be held with a small wire staple across the print and pushed into the sand. As only one end connects with the sand, the other being completely surrounded by metal, special attention must be paid to the venting and the reinforcing. A tiny bit of wire is a big insurance against a spoiled casting!

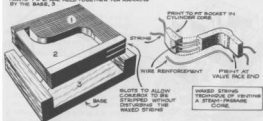
The same arrangement would be employed for a straight-through core which fell above or below the parting line but a smaller print at each end would be adequate.

Sketch 46. When a core of complex shape does not allow for pierced venting in the manner so far described the waxed string or 'strum' (as it is sometimes called) technique can be exploited. Such a core box is shown here and, like that shown in sketch 43, it is made in three parts. Parts one and two are the actual core formers and to retain them during the process of ramming they are held within the base, three. The core making commences with a layer of sand pressed firmly into the shape. A length of waxed string is now passed into the lower slot and out the other end following the middle of the core. This is embedded in a further thin layer of sand to about centre height when a previously formed piece of wire is also embedded in the sand following the contour. A second length of string is fed in over this and then the core completed with sand and smoothed off at the top.

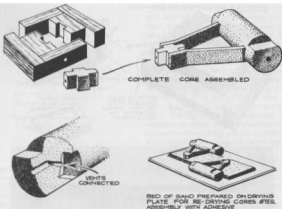
In a production foundry a simple jig

PARTS 1 & 2, ARE HELD TOGETHER FOR RAMMING
BY THE BASE, 3

46



Small ex-domestic electric oven in use as core stove.



would be completed in the pattern shop for ensuring that each piece of reinforcing wire would conform to the correct shape. When it is important that the wire does not twist within the core it is given a small loop at each end.

To improve the finish of sand cores after baking they may be given a coating of refractory wash. The wash also allows the core to be stripped more easily from the casting and reduces sand inclusion in the metal with a resultant longer life to the tools used for machining.

The wash usually consists, for the most part, of plumbago to which may be added a varying proportion of French chalk. It is mixed with some sort of binder, such as sodium silicate or thinned coregum, to a brushing consistency. Likewise, of course, a proprietary core wash can be used.

Cores so treated must be stoved again before they can be applied to the mould.

Care taken is well repaid

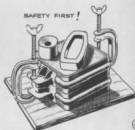
The making of a greensand mould, particularly when baked cores are included, calls for a considerable expenditure of time — to say nothing of energy. All the effort is wasted if the resulting casting is faulty. Every possible step should therefore be taken to reduce the risk of a fault occurring by paying careful attention to detail at all stages. In this respect the strength of a core is always of the utmost importance. All other things being satisfactory, a dislodged or broken core will ruin an otherwise perfect casting.

It is therefore sound common sense to take all practical steps to see that every baked core is reinforced against breakage. Iron wire of about 18 to 20 gauge will

give adequate support to the type of core discussed here.

As a final measure of precaution every mould should be clamped before pouring to guard against the weight of the incoming metal forcing the mould apart, as indeed it can do with a consequential run-out.

Where clamps cannot be applied to a box, because the size of the lugs do not allow it, the mould should be weighted over the top. It is even advisable to place weights on the sand itself when clamps are used. When moulds are made in small and shallow boxes there are often occasions when the cavity comes very close to the upper surface of the sand. At this point a breakthrough is always possible, particularly when an extended sprue is used to give more 'head'!





A pot of iron from the furnace.



Pouring the iron. An assistant holds back the dross.

CHAPTER 5

Casting Locomotive Cylinders

It is likely that many readers of this book will be model engineers with a particular interest in the building of miniature locomotives. It is possible, too, that if they are contemplating the question of establishing themselves with foundry facilities it is castings for these models which will most interest them. There is a long list of components for locomotives for which casting would be desirable: cylinders, wheels, horn blocks, axle boxes, eccentric sheaves and so on. But of these the greatest importance would probably be attached to the casting of cylinders and wheels.

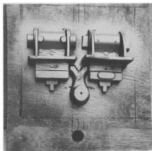
Both of these items present their own special problems to the amateur foundryman and by no means the least of these are the problems associated with the casting of cylinders with their cored cylinder bore and the steam passages. If the modeller is prepared to accept limitations in his foundrywork and be satisfied with cored cylinders only, being prepared to excavate the steam passages by other means from the solid metal, then the project becomes much less formidable. Having prepared the patterns, all that would be called for would be a couple of straight-through cores. But, although perhaps something of a challenge, the

coring of the steam passages as well is always possible, even for very small cylinders.

There can be no typical example to expound and no hard and fast rule. All that can be done is to explain the process involved in producing castings of a particular cylinder in as much detail as possible. Then if you feel like tackling a similar project for yourself you will have useful notes to follow or, perhaps, adapt to suit your own requirements.

As regards the pattern-making and moulding, it will make little difference to the process in whatever metal it is contemplated to make the castings. The main concern would be the matter of shrinkage and the dimensional allowances to be made for it.

The possibility of casting successful locomotive cylinders in light alloy should not be ignored if the melting facilities of a small foundry end there. The structural quality of the material would seem to be quite adequate and, with normal attention paid to lagging and cylinders and port faces lined with more suitable metal according to the preference of the builder, there seems little doubt that the mechanical quality would also be adequate. Examples of light alloy locomotive cylin-



Pattern for cylinders for Hunslet Holy War. An example of a single-sided pattern plate.

ders are known to exist and, so far as can be ascertained, they give complete satisfaction to their builders.

Bronze and gunmetal are almost traditional materials for the casting of miniature cylinders but, for the project in hand, hoping to conform to the prototype as closely as possible, it was decided to cast in iron.

New drawings were first prepared, scaling down the original builder's plans, which were full size, to the dimensions for the model, incorporating any adjustments to the design considered appropriate to the reduced scale. The first new drawing, sketch 49, shows the cylinder as it should be in working order. This serves as an important guide when shrinkage and extra metal for machining have to be allowed for in the pattern. This is made clear in the duplicate set of drawings for the pattern.

It is quite certain, when the plans of the prototype are examined, that separate patterns at that time were prepared for

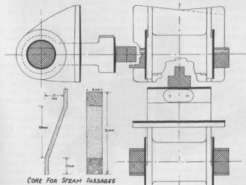
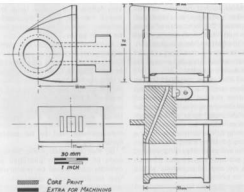
each cylinder. Roughly made patterns have been deplored in this book, but not economical patterns! The design can be examined at this stage to see if it is at all possible to reproduce a pair of cylinders from one pattern. These cylinders are opposites and the most striking variation between them is undoubtedly the mounting flange. Minor details can comfortably be taken care of in machining.

The cylinder drawings shown are for a 3½" gauge Hunslet built originally for a gauge of 1'10¼". The prototype locomotive was constructed around the turn of the century.

It was decided that with some small adjustment it would be possible to cast left- and right-hand cylinders from one pattern. These cylinders are mounted at an incline of 6° and therefore the top edge has a slope at an angle of 6° to the bore. Reference to the drawing for the pattern will show that the solution adopted was to add the 6° angle to the front and rear of the pattern equally from the centre-line. Relating the left- and right-hand cylinders was now simply a matter of sawing off the excess material from one side or the other.

The working drawing has itself been simplified and modified from the maker's designs, notably in the matter of the steam chests. In the original locomotive they were cast in one with the rest of the cylinder block. There are problems associated with the internal machining of such steam chests which led to the adoption of the bolted-on steam chest in preference.

Steam passages on the full-size locomotive from cylinder to port face were a foot long. They were ¼" wide and 3½" deep. The scale adopted for the model was 4 mm to the inch, which reduced the cored passages to 48 mm × 14 mm × 3 mm. The total length of each core



over prints was 74 mm (3").

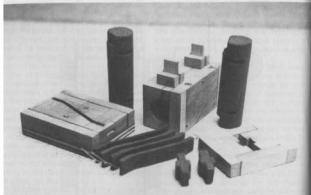
The makers also webbed the underside of the port block so that the cross-section of the steam passages was box-like. To have repeated this in an area of about 2" x 1/2" would have needed three small recesses in the pattern. As a further concession to economy this part of the pattern was instead left solid except for the cored steam passages.

Cores had also to be prepared for the cylinder bores and the exhaust cavity. Cylinder cores needed to be provided with slots at either end in which could be located the extended ends of the steam passage cores which served as prints. The positioning of the slots allowed for a working bore of 48 mm between ports. Loco builders will probably recognise and agree that producing passages of such dimensions by any other means would

be extraordinarily difficult. For those who might hesitate, however, it may reasonably follow that if such long, thin passages can be cored successfully by amateur means, shorter ones may well be much easier.

Allowance made on the pattern for subsequent machining was as follows. Diameter of core 24 mm for a finished bore of 28 mm. Cylinder end flanges are 2 mm thicker than the final size. Two mm has been added to the port face for machining and the same increase incorporated in the reverse of the mounting flange although, as this feature is to appear upright in the mould, the extra measurement had to be arranged to include draught.

So that the relationship between the ends of the steam passages and the cylinder core would be preserved, both



ore boxes and cores for the pair of cylinders.



As cast in iron. Note the extra thick sprue for metal for pistons and rings.

ends of the latter were provided with flats. The core for the exhaust port was made to overhang into the mould. The cavity thus formed is rectangular, leaving the matter of the exhaust outlet to subsequent drilling of the casting. But these cores have another function. They have a wide core print to govern the correct spacing of the steam passages on the port block and thus the valve events.

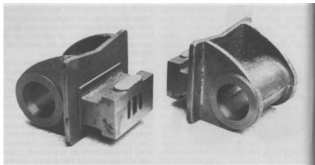
The patterns themselves were made in two halves in the manner described in Chapter Two. Clear polythene was stretched over the actual drawing and the parts of the first half-pattern assembled on that using PVA adhesive. A square was used constantly to check that vertical faces did not wander while the glue was setting and that, at least, a small draught was present where it ought to be. The two halves of the cylinder had, of course, been turned as one with their retaining dowels. Once the upper half of the pattern was satisfactorily assembled and set it was removed from the drawing

board and, using the existing dowel holes as a guide, the lower part was now built up on the upturned underside of it. Polythene was again employed as a separator to prevent the two parts from sticking together.

The photograph on page 52 shows the finished patterns mounted side by side in the manner described for the turn-over plate. The plate carries a somewhat extended sprue boss which would, of course be repeated above and below the parting line. This was to ensure that the run of the castings would be complete right to the highest part of the flanges. The ingates were generous to the same end. The positions of the dowel holes can still be seen on the pattern on the right and it will be noted that a third dowel has been added to the port block.

The photograph on this page also shows the double casting as it emerged from the mould. Extra height has also been added to the pouring head. The enlarged section of iron in the middle of the sprue has been provided to supply metal for pistons and rings.

However, it was, undoubtedly, the cores which called both for the most careful thought and care in execution. To make them sifted builders' sand was mixed with Fordath Cream No. 444 to a manageable consistency (approximately 3 oz cream to 1 lb dry sand). Cylinder cores did not present as much of a problem. Sketch 49 shows how the loose parts of the core box were arranged to leave the sockets in the cores, which were vented in the core box by making a $\frac{1}{4}$ " hole right through. After baking the cores were further vented at the fettling stage by piercing the backs of the two sockets to connect with the main vent. Free escape of the gases where the cores connect is of the utmost importance, because they will be completely sur-



Partly machined cylinders showing the cored ports.

rounded by metal.

For venting the steam-passage cores the waxed string technique was employed and each core was strengthened by the inclusion of a length of florist's wire bent to shape. This can be obtained from garden centres. It is a soft iron wire of .040" diameter. The core for the exhaust cavity was vented from the print end with a $\frac{1}{16}$ " wire, leaving about $\frac{1}{8}$ " of solid core at the end which penetrates the mould.

Usually, apart perhaps from removing a bit of flash from the joint line of a core, it can be inserted in the mould just as it is baked. But cores of this kind may call for some fettling. The square edges may be rather sharp and, in relation to a core of such small section, have a considerable flashing. With the aid of an old file or, perhaps, a sandpaper block the extra sand can be removed and the edges slightly rounded to a better passageway section. One end of each thin core is fitted to its socket in the main cylinder

core and some filing is likely to be needed here as baked sand does not slide easily into baked sand.

The extremities representing the valve ports are now brought together on either side of the exhaust core and the file applied as needed until they are spaced in accordance with the drawing, parallel and vertical.

If the parts of the core are all assembled before inserting them in the mould they can be fixed together with core gum. It is unlikely that the small-scale foundryman will go to the trouble of acquiring a proprietary core adhesive for the limited use he will have for it. But the joints and the contact faces can be coated lightly with flour paste or a slightly thinned core cream and this will hold them. Before use, however, the whole core must again be transferred to the stove for drying.

Sagging must be prevented and for this a sand bed is prepared on a flat metal plate for supporting the cores in the oven. Although gum has been used, a couple

of turns of thin fuse wire round the assembled prints at the valve end will prevent spreading.

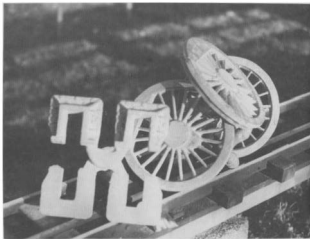
This sort of job should never be rushed. Cores can be made in plenty of time well ahead of the moulding session. Trial assembly can be made to make sure that it is going to be possible to use them in conjunction with the pattern as first prepared. Never lose sight of the possibility that the pattern may well still be altered

to advantage. A good deal of this kind of venture can always be experimental.

As far as the availability of flasks will allow, the moulds should also be prepared in advance. They will be better than those prepared in a hurry while the melting is in progress. Protect each prepared mould with a sheet of plywood or similar to ensure that no foreign body falls down the pouring sprue.



Machined wheel castings for a 5" gauge Hunslet.



Wheels and axle horns for an "A 5" Pacific. Joe Holdsworth.

CHAPTER 6

Wheels

As long as all the contours and details on it are concentric with the rim, the wheel – in its simplest form, the disc – demands little comment as regards either pattern making or moulding. By and large the pattern represents a simple wood turning job and often, for the making of the mould, a loose pattern can be treated as a one-sided pattern. If it extends to any large degree above and below the parting line and a split pattern is called for, this can usually be arranged to register with a dowel at its own axis.

When more than one casting of the same wheel is needed you should not lose sight of the possible advantages offered by the use of a pattern plate. A recommendation is to have one or two spare plates not occupied by permanent patterns always to hand, upon which can be mounted temporarily various simple patterns as the need arises. Very often it will also be found possible to utilise an existing ingate pattern. There is little question that, once the plate is prepared, making the mould is much facilitated.

Mount the wheel offset on the plate and the duplicate can be moulded and cast in one operation. The plate is divided at a centre-line running through the pins and, as long as the pattern does not

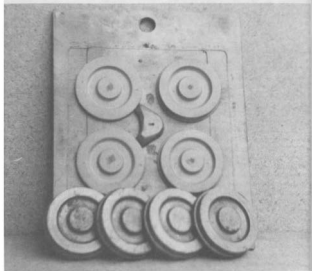
overlap this line on one half of the plate, the same can be turned over after ramming the first half of the flask and the duplicate wheel moulded in the second half.

A development of this is shown in the photograph overleaf of the one-sided plate which moulds a set of four wheels from two patterns, but they are split patterns. Sketch 50 shows how the wheels, in this particular case, have been divided in the pattern at roughly the middle of the flange.

Where two identical patterns (or two pairs of patterns as the case may be) are required for a plate of this kind there is a choice of either turning two at the outset or of moulding a second from plaster of Paris. In many cases, without a doubt, it is more convenient simply to continue turning while at the lathe. But if plaster is used it should be finished off after drying with shellac or varnish in the same way as the wooden pattern. Unless it is carelessly knocked about or otherwise accidentally damaged it will probably be as durable as wood. Perhaps the plaster duplicate has more value when the pattern in question is more complicated than a simple disc wheel. There are, in fact, special hard plasters available to the foundry trade for pattern making.

A much greater problem exists at all stages when the wheel has spokes or arms. If the spokes are sturdy in section and few in number the obstacles in the way of preparing a loose replica pattern are not so great. Usually the pattern can be confined to a basic disc of flat wood of appropriate thickness, such as plywood, from which the arms are fretted. The turned rim and hub are built up on both sides of the disc and the whole probably skimmed off on the lathe to complete.

Moulding such a wheel can be more of a problem, particularly if it has oval spokes and deep contours on both sides, for then it has to be treated very much as an oddside. The first part of the box can, perhaps, be rammed up in the usual way but when it is inverted it will be found that much of the original sand has found its way through the spokes and formed a ring of sand 'cheeses' that have to be cleared away. The sand between the spokes has to be firmed up and an arbitrary parting line fixed and levelled



A single-sided pattern plate to mould four iron disc wheels.

individually between each spoke. All in all this can be regarded as a tedious operation but by no means beyond the acquired ability of the home foundryman. It must be admitted, however, that the matter does become a little more exacting as the number of spokes increases in the wheel.

A much greater problem arises when a spoked locomotive wheel is required, not only from the point of view of moulding but of the pattern making as well. It may carry a large number of spokes, perhaps as many as twenty-four. Proportionally these are quite fine in cross-section compared with the hub and rim of the wheel. A further complication is likely to be the addition of crank webs and balance weights. A wheel is characteristic of the particular locomotive being modelled and true realism can only be achieved by following closely photographs and carefully made drawings of the prototype.

With all the relevant information available there still remains the challenging work of making a pattern. The making of full-size patterns for locomotive wheels represents an example of very fine carpentry. Each individual spoke and detail is shaped precisely to the drawing and mitred to its neighbours and the hub and rim. It would probably be a very brave man indeed who would engage himself in the task of reproducing the technique in a wheel pattern of, maybe, only 6" in diameter. He would be much more likely to adopt the more obvious course of carving the spokes from a previously turned wooden disc. The photograph on page 63 shows two wheel patterns; the larger one has twenty spokes and there is a casting of the smaller one, made in exactly this way from seasoned mahogany. Excellent castings have been made from these but it is emphasised that such patterns demand a careful

and knowledgeable moulder. An expert, in fact!

Taking the wheel blank as turned, the spokes must be marked out accurately on the wood. Looking at the front of the wheel it is likely that the area to be spoked is recessed below the rim and hub. The actual drawing can, perhaps, be carried out more conveniently on cartridge paper that can be cut to the shape of the recess and glued on the wheel. The next logical sequence is to mark out and drill a series of small holes to represent the radii at the root and extremity of each spoke. Very great care must be exercised in making sure that these holes do not encroach on the wood from which the spokes have to be carved. The holes also serve to admit the blade of the fine saw which will be needed to remove the waste wood between the spokes. Very straight and accurate sawing is called for and it is advisable to cut within the waste to allow material for final shaping and cleaning up.

A small template is made to the required section for the finished spokes and they can be carefully filed and sanded to their correct profile. The spokes are likely to be tapered from the centre to the periphery and, to be really meticulous, a series of, perhaps, three templates would need to be used. Usually, however, the spokes are finished to a degree at which they present a pleasing appearance to the eye.

Difficulties may occur due to the fact that, while two of the spokes can be arranged to lie in direct line with the wood grain, all the rest must be cut at a varying angle to it. It is possible for the angled grain to have the effect of tending to control the cutting of the tools used for shaping. This may result in some slight imperfections in the straightness of the spokes. Some improvement can be

achieved by building up the initial blank from a series of segments glued together.

In view of the great care that has to be exercised in moulding an oval section spoke in the manner already described, some economy of effort can be achieved by shaping the fronts of the spokes only and leaving the back of the wheel flat. Castings from this type of pattern are usually quite acceptable as only with the closest scrutiny can the discrepancy be observed when a model locomotive has been finished. A little judicious fettling with a fine file can render the general effect quite acceptable.

Whether the spokes have flat backs or whether they are of a true profile, the moulding of a wheel, as with so many other kinds of pattern, can be very much simplified for the less accomplished moulder. A flat-backed wheel of the manner already described can simply be mounted on a plate for moulding. It is necessary to bring the actual spokes into contact with the plate and for this the whole back of the wheel must be flat. This may entail turning off the back of the flange and hub and substituting copies of these two features on the reverse of the plate.

If the use of a plate is decided upon at the outset, however, there need be no question about the section of the spokes. The method of preparing the pattern is different and it can be arranged that only half the spoke depth is represented on each side of the plate. In fact, the oval section spoke can be moulded even more readily than the flat spoke.

It should be acknowledged at this point that no attempt is made here to describe how to represent all the meticulous detail which might be applied to the pattern of a model locomotive wheel. How exactly his pattern will conform to the spoke arrangement, fillets, webs and so on of

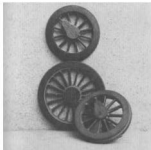
the wheel he has chosen must remain the prerogative of the modeller. That which is here described is a basic method by which a person with little foundry experience can provide himself with a wheel pattern, not too laborious to make, which he will be able to mould and cast satisfactorily. It could be said, in fact, 'wheels without tears!'

The plate pattern for spoked wheels in the photograph on page 64 moulds a pair of wheels at a time by the turn-over process. There are patterns on one side of the plate only and the wheel produced has twelve oval section spokes and is 3½" diameter over the flange. The casting shown on the right of the group has been machined to size.

This sort of multiple pattern is clearly an advantage when the number of flasks available is limited. With the size of box being described, however, this is the largest wheel which can be accommodated as a pair. The difference as regards the preparation of the pattern is that, of course, in the present instance the front and back of the wheel will be seen side by side whereas, with the single wheel pattern, the reverse of the wheel will be situated on the underside of the plate, concentrically with the front. The method of laying out the pattern in each case is the same.

The wheel is built up entirely on the plate, commencing with the inscribing of its position by its centre and its main circumference. Its centre is confirmed by a drilling which will be used for establishing the reverse side or for the turn-over template as described in Chapter Three.

The tyre and flange are turned independently against a temporary stout plywood backplate, so that they can be parted off horizontally in the form of two rings. Each is given an appropriate draught relative to the way it will be mounted on



Two carved spoked wheel patterns in mahogany by Andrew Todd and a commercial iron casting from one of them.

the plate. They can be turned to their finished section and sanded smooth. The fore and after parts of the hub can also be turned separately and each provided with a central drilling to match the centre hole already pierced in the plate.

Separate spokes

To arrive at a positive alignment of the spokes a special template is prepared on a thin sheet of plywood, say, 1 mm or $\frac{1}{16}$ ". The complete drawing can be transferred to this or the wheel outlined thereon, dividing it with radial lines to represent the spoke centres. The template is drilled through its own centre with a diameter of hole the same as the wheel centre established on the plate. One can then be located exactly above the other. The template is further pierced with small holes, just large enough to accept a scribe point, at the base and extremity of each spoke. The template will now carry two rings of holes; the inner ring

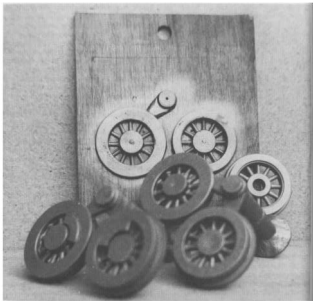
just clear of the periphery of the hub so that the latter, when placed in position, will not obscure marks made by the scribe through the holes. The outer ring likewise will be just within the inner rim of the wheel. Joining up the two rows of points scribed through the template establishes the centres of the spokes.

To be quite certain that the spokes will register accurately with each other on both sides of the plate, it is only a matter of making sure the template is not rotated by drilling one datum hole on the horizontal centre-line through template and plate together.

The front and back of the wheel are now built up separately, although it may be an advantage to complete one side first. The hub discs and turned rims are glued to the plate following the concentric circles already drawn. Clearly care is needed at this point to ensure that the rims are truly concentric with the hubs. Crank webs and balance weights are disregarded at present and the wheel is built quite plain with equal length spokes.

The parting line of the mould does not run through the actual cross-sectional centre of the wheel. Therefore the depth of the components on the front of the plate will be greater than those of the back. Likewise the thickness of each spoke will be shared unequally, according to the design of the wheel to be followed, between front and back of the pattern. The usual spoke section is oval or egg-shaped, some being brought to a slightly pointed crest at the outside of the wheel.

For a twenty-spoke wheel, forty half-spokes have to be made. The work may sound formidable but that need not be so. A timber such as obechi is recommended and it is probable that this can be purchased as a strip-wood of an appropriate square or rectangular section. With a simple jig it is possible to ensure



A group of iron wheels cast from the single-sided plate. The webs have since been removed from the pattern.

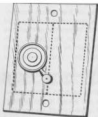
the cutting of forty equal-length blanks from the strip.

A metal 'mould' is made to govern the shaping of each spoke to an identical cross-section. Sketch 50 shows the form that this simple device takes. It will be noticed that it also reproduces the taper of each spoke as well. Mild steel is a

satisfactory material for it as the actual shaping of the spokes can well be accomplished with a sandpaper block or light filing. In practice the mould is not visibly eroded by the process. A similar, though shallower, jig can be made for forming the back of the spokes although, except for the most meticulous modeller,



SECTION OF WHEEL PATTERN DIVIDED FOR MOUNTING SIDE BY SIDE ON A SINGLE 6x4x2 PLATE



POSITION OF PATTERN AND SPOKE ON A "TURN OVER" PLATE



SEPARATE DISC AND HUBB
THE BUILT-UP WHEEL PATTERN

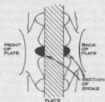
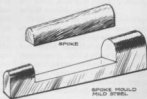


DIAGRAM TO SHOW SPOKE DIVIDED BETWEEN FRONT AND BACK OF PLATE



DIAGRAM TO SHOW DIVISION OF WHEEL AS MOUNTED ON PLATE



these may well be shaped freehand.

The completing of the wheel now involves gluing the spokes in place guided by the radial lines. When the adhesive is firm fillets or radii can be applied with wood filler and the whole finally smoothed with fine sandpaper and shellac or cellulose sealer.

Upon such a basic wheel pattern it is possible to dispose other details such as crank webs and balance weights as required. These are added in the form of flat cut-outs of plywood of appropriate thickness and shape. They are positioned with small woodscrews or pinned so that they can be removed and replaced. The spaces underneath them and between the spokes are filled in with plasticine or plaster of Paris, which will not adhere permanently to the varnished pattern. The draught is made good with paraffin wax run in and smoothed to shape while it is still warm. Dental wax is ideal for the purpose. If the pattern has been cellulose finished the additions can be further protected with shellac as this is soluble in methylated spirit and can removed if alterations to the pattern are needed.

The multiple pattern plate can carry the usual ingate pattern. In that way all wheels will be poured to the flange. It will be noted that with a turn-over plate only one ingate pattern is needed per pair of wheels. When the plate is inverted for moulding the other side the ingate is duplicated to the second wheel.

A single wheel can be poured satisfactorily from a sprue connecting directly with the wheel centre. The hub of the pattern can be provided with a shallow hole to accept the peg of the sprue stick.

When casting iron spoked wheels it is essential that the metal is poured at a very high temperature to be sure of a complete run. With regard to the home furnace this will probably be close to the greatest heat it is possible to attain.

It is sometimes wise to make a test pour to prove the mould. Light alloy melts much easier and will run quite fully at normal pouring temperature. This will allow any slight faults which may become apparent to be corrected before more time and trouble is expended on firing up a solid fuel furnace.

CHAPTER 7

Metal, The Furnace and Melting

In Chapter Two the importance of pattern making and how it relates to the finished work was carefully emphasised. But equal in importance must be the melting of the metal, its quality and, of course, the quantity.

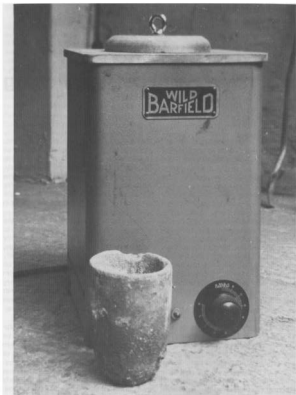
For the purpose of this book, and with due regard to the possible melting facilities available to the home foundry, the metals likely to be encountered are divided into three broad categories. In an ascending scale of melting temperatures the first of these are the 'light alloys', alloys of which aluminium forms the basic metal, usually over 90 per cent, with small additions of copper and/or zinc according to the kind of duty for which it is originally intended. These have a melting temperature around 1,200°F.

The amateur foundryman usually obtains his supply of light alloys from scrap. The actual composition of this material as received is never known. The only guide available as to its suitability for the application intended is probably the awareness of its original duty. Large quantities of it derive from the motorcar industry and, for most general purposes, satisfactory castings can be made from re-melted crankcases, gearbox castings and so on. Pistons from all sizes of internal

combustion engine make good re-melting, and if great care to avoid contamination is exercised, it is possible to re-use this material for castings with special duty. If a known specification is called for aluminium alloys can also be obtained for the home foundry in ingot form. The photograph on page 70 shows ingots in LM 4 alloy from Kemwell Ltd.

Still at the lower end of the melting scale, it may well be valid to refer to alloys which fuse at temperatures slightly below that of the so-called light alloys. Scrap zinc-based alloys of the type usually associated with die castings can also be cast in sand. Experience gained from experiment, although no confirmatory information can be given, suggests that this material may be used with success for small machine parts, pulleys, gear-wheel blanks, etc.

From the point of view of melting equipment, zinc-based alloys can safely be classed along with the alloys of aluminium but alloys containing a percentage of magnesium, on the other hand, may present difficulties. It has been noticed that some of them tend to burst spectacularly into flame when exposed to the atmosphere at materially above their melting point.



A commercial muffle furnace suitable for melting light alloy.

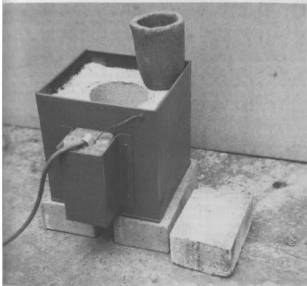
Cuprous alloys

The next category in the scale of temperatures are the alloys of which copper forms the basis. These include a wide variety of brasses where the proportion of copper varies from as low as 55% according to their duty. The remaining constituent is usually zinc with, sometimes, small additions of tin and lead. The melting range commences at around 1,600°F (870°C) for brass and rises to

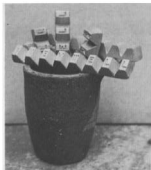
1,800°F (1,000°C) for the various kinds of bronze and for gunmetal. Pure copper itself, of course, has a higher melting point still at about 2,000°F (1,090°C).

A furnace for aluminium

Many of you will be well aware that aluminium alloys can easily be melted in a household open fire. Reduced to 'rough and ready' proportions such receptacles as an empty food can or the inside of an



The 'discuit tin' furnace.



LM4 light alloy ingots and a Salamander crucible.

old-fashioned glue-pot have been known to serve as a crucible. Buried in the cinders of a well established coal fire, certainly the metal melts. Stirred with a piece of wire and skimmed off – perhaps with an old spoon – it looks silvery, clean and ready for pouring. It is not until the resultant casting is cooled and machining commences that the first problems are encountered, when the casting is found to be exceedingly porous and full of included particles of foreign matter.

The fact is, of course, that aluminium alloys are extremely susceptible to adverse melting conditions. They will pick up and absorb impurities even from the atmosphere of the furnace. Under better conditions, when a plumbago crucible is used in a clean coke fire and the pot kept covered with a lid – except for re-charging – the metal will still tend to be spoiled by porosity. In the early days of casting of aluminium alloys some porosity

was indeed regarded as unavoidable even in the commercial foundry.

The use of iron and steel melting pots for light alloys should be avoided unless the metal is protected from direct contact with the interior of the vessel by the use of a refractory wash. Molten aluminium alloys can absorb iron in a way that produces a coarse-grained brittle material. Thus iron stirrers, skimmers, plungers and so on should also be avoided unless these, too, can be protected by a refractory wash in the same way.

A refractory wash such as 'Firit' can be obtained from foundry suppliers in the form of a dry, white powder which is mixed roughly fifty-fifty with water to a brushable consistency. It is applied by brushing or dipping the previously heated utensils, several coats being built up until a suitable protective thickness is obtained. The coating is likely to have to be renewed from time to time during working.

By and large the best results are obtained by melting light alloys in the cleanest possible conditions. Illustrated in the photograph on page 68 is a 1½ kilowatt muffle type electric furnace by Wild Barfield. This will accept an old-type No. 6 crucible having an outside diameter of 4½" and a height of 6", equivalent to a capacity of 12 lb measured in copper. The interior of the furnace itself is 5" diameter by 11" deep. (A similar size of crucible in the Salamander range is the A4 which lacks a little in height.)

In order to make use of the available diameter of the furnace interior it makes good sense to fabricate a pair of special tongs as illustrated in sketch 51. One kind has the jaws offset to grip the crucible on one side and to distribute the weight. These are made wide and curved to fit the particular crucible in use. Such tongs are only used for handling the pot

into and out of the muffle. For pouring it is transferred to grip-tongs or a shank.

In use the crucible is placed empty in the furnace and the heat switched fully on. The electricity consumption is low and it may take an hour or so for a melting temperature to be reached. Meanwhile as it heats up and begins to show red in the region around the crucible the initial charge can be added. Scrap metal must not be charged into the pot so that it can jam against the sides, otherwise, as it expands, it may crack the crucible. Once a pool has been established in the bottom of the pot more metal can be added and it will be seen to melt quite quickly.

It is found with this type of muffle furnace that, since the furnace atmosphere is so clean, as long as no dirt or rubbish is added with the scrap, the resultant metal will be pretty sound and will have a good texture on machining. For even better results a proprietary chemical de-gasser can be used in accordance with the instructions accompanying the product. Risk of metal contamination is minimised by the use of a flat piece of hardwood or a wooden rake for skimming off the dross when the crucible stands clear of the furnace prior to pouring.

Earlier experiments with the muffle type electric furnace for the melting of aluminium alloys resulted in the 'biscuit tin' furnace illustrated on page 69. This proved to be usable and, in fact, still exists. The muffle itself is in the form of a fire-clay tube moulded over a split former, which was afterwards collapsed for the removal of the tube when dry. A proprietary brand of fire-clay will do this job admirably. The biscuit tin is roughly 9" square and is tall enough to receive a tubular muffle 7" high with an internal diameter of 4". The source of heat is a one-kilowatt coiled element stretched out, the turns round the outside of the

muffle being separated, one from the other, by turns of asbestos string. Lead-in wires from an ex-electric cooker connector are nut and bolted to the ends of the element and insulated with ceramic beads. The muffle stands on a layer of 'soft' firebrick sawn to the required thickness and is packed around with a dry aggregate of finely broken firebrick. Another firebrick forms a cover to retain the heat while the melting is in progress.

With a current consumption as low as this, although the heating-up time is slow, at maximum temperature the furnace will be found to be virtually self-regulating. The heat dissipation seems to balance the input and it can be almost continually in use without overheating.

Another home-built muffle furnace is illustrated. The photograph on page 73 shows the furnace built by Eric Smith in North Wales on the lines of the simple furnace just described. The interior measurements are similar to those of the Wild



Muffle for Eric Smith's furnace showing element connections on copper bands.

Barfield and it is contained within a specially fabricated steel case. Lifting handles are incorporated as well as an on-off switch with indicator light. The element wire used in this furnace has a consumption of 1½ kW.

Note the lifting tongs specially made to suit the furnace interior diameter as well as the particular size of crucible.

Gas fired

Moving into the higher range of melting temperatures now, that of the cuprous alloys, it is unlikely that adequate heat can be raised in an ordinary electric muffle of the type described. Solid fuel can be made to reach temperatures very much higher, of course, but an extensive use is being made of the convenience of gas. The drawing shown (sketch 51) is of a small gas furnace designed by Andrew Todd, who has the advantage of a lifetime's experience in both technical and practical sides of the gas industry. The sketch concentrates only on the burners and the gas supply that could, obviously, be built into an existing furnace of suitable size.

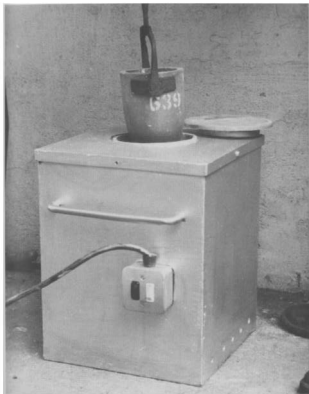
This furnace is intended to operate on natural gas plus an air supply of 1 lb per square inch from a rotary blower. The pressure is very low but the volume of air is appreciable. It incorporates a Venturi (gas and air) Mixing Chamber by Keith Blackman of London and employs two No. 4 burners. Each burner consumes 40,000 BTUs an hour, making a total gas consumption of 80,000 BTUs, or just under one therm per hour. The burners are arranged opposite one another but staggered to produce a vortex of flame. A form of regenerator is incorporated in the furnace cover where the incoming air is pre-heated. The proportion of gas to air is one to ten. The cover swivels away for access to the interior of the furnace.

A non-return valve must be fitted in the gas line as close as reasonably possible to the furnace. In the event of a blockage in the burners the valve will avoid the possibility of air finding its way into the gas supply and prevent an explosive mixture being formed in the gas main.

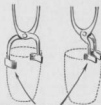
The desirability of being able to produce sound castings in brass and bronze in the home foundry cannot be denied. Although cuprous alloys will be found, as a general rule, to cast very well there are a number of problems associated with the melting of the material for the resolution of which there can be little substitute for experience. If the source of metal is to be scrap, which is likely, then this has to be sorted visually to separate brass from bronze and gunmetal. If the original use of the items which have been scrapped is known, that will serve as a guide. Bushes, gearwheels and so on are probably known to be bronze, and largely scrap brass will be identified from its colour as well as its original duty.

The difference between the various copper based metals is, of course, in the metal with which they are alloyed and the proportion of it. Brass, for example, may contain from 27% to 45% of zinc according to the use for which it was intended. If it is in the form of scrap castings an unknown percentage of its zinc may have been lost already as it tends to volatilise from the molten alloy. Further losses are likely in the re-melting, particularly if the temperature is not closely controlled. In the absence of a suitable pyrometer only careful and experienced observation of the appearance of the metal at pouring temperature will help to produce good castings.

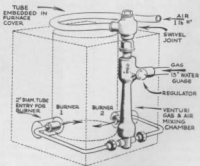
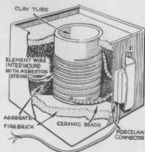
Coupled with careful melting, zinc losses can be restricted by the use of covering flux during melting. Fluxes for brass or bronze are available from foundry



Home-made muffle furnace by Eric Smith.



SPADES CURVED TO SUIT
PARTICULAR CRUCIBLE IN
USE



suppliers who may, with advantage, be contacted at the outset.

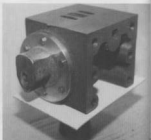
The range and variety of bronzes is very great and the difference between some bronzes and gunmetal may be as small as 1% of tin! Clearly, without some analytical apparatus, it would hardly seem practical to sort out the various grades from an accumulation of scrap. Recast bronze from scrap, therefore, would finish up simply as – bronze – with a very general purpose and indifferent characteristics. It would differ from brass mainly in that it would contain little or no zinc but, perhaps, 10–11% tin. There may also be lead present in a small proportion.

As with brass, great care has to be taken not materially to exceed the melting

temperature but it should be appreciated that the best pouring temperature, about 2,000°F (1,200°C), may well be much higher than that at which the metal melts. The temperatures given in this book, although reasonably accurate, are really only included for information. Obviously, the knowledge of what the correct melting temperature of a metal should be does nothing towards warming it up. It still needs heat applied until it does melt. Those with access to a pyrometer are advised to obtain accurate information on optimum melting temperatures. Manufacturers of special fluxes and refining agents usually supply this information free along with their products.



Joe Holdsworth's cutter grinder entirely built from home-made castings.



Cylinders for a popular 5" narrow gauge model.

CHAPTER 8

A Solid Fuel Furnace

At the higher end of the temperature scale ferrous metals require the most heat for melting and even a certain amount of super-heating to obtain a good pour and castings which are fully run. In this respect, from the point of view of both economy and convenience, the solid fuel furnace is still probably the most useful to the home foundryman.

The fuel must be a high quality furnace coke which, unfortunately, does not nowadays seem to be marketed freely. One seems to need to be 'in the know' to get an occasional bagfull. But some special cokes obtainable from the domestic supplier, known variously as Sunbrite, Hot-glow, Stovesse and so on, have been found serviceable. Old-fashioned gas coke, if available, is not suitable as it clinkers up too badly and the furnace soon ceases to function through being choked.

A solid fuel furnace, to conform to typical practice, would be in a pit, the cover of the furnace being at floor level. The flue is built behind it and the pit has to be roomy enough to allow the access of the furnace man for cleaning out the ash and other attention. The operator stands at floor level for manipulating the crucible. A traditional pit furnace, there-

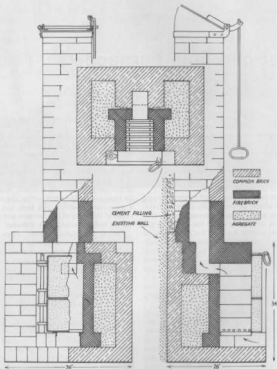
fore, would be largely impractical for the home foundry.

A similar effect could be produced with a furnace stood on the floor, perhaps built into a flue or exhausting into the open air. But a furnace of substantial size built in this way and adequately insulated to retain the heat means that the operator is obliged to handle the crucible, likely to be heavy as well as hot, while already in a semi-bent position. His feet, too, are close to the base of the furnace and accidental spillage could be a disaster.

Taking into consideration these and several other factors it was decided to try to design a furnace standing above the floor which would offer easy access for firing, charging and cleaning and for a second person, if necessary, to assist in handling the crucible.

Believing that the arrangement of this furnace is sufficiently effective for it to be worthy of consideration in the establishment of a small foundry anywhere, a full drawing is shown overleaf.

The design includes a brick flue and this is surmounted with a hinged cover actually intended to keep out the weather. Previous outdoor furnaces have all deteriorated badly from the effect of the climate. The bricks and the lining become



saturated, which probably leads to them breaking up in the intense heat when, perhaps after a lapse of many months, the furnace is started up again. There is a long handle for opening and closing the lid from below. Fire lighting is with sticks and a few pieces of coal in the usual way and the chimney provides plenty of

draught for this. It also helps to maintain a hot fire when the forced draught is shut off between melts. Experience has shown that a furnace exhausting directly into the open air can be uncomfortably hot to the operator working in close proximity, so the chimney also serves to keep the operator cool.



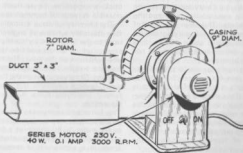
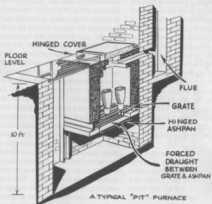
The flue cover closed.



The crucible is set up on a piece of firebrick.

The whole front of the furnace hinges outwards in the manner of a stable door, that is to say, in two parts. The hinge takes the form of a $\frac{3}{4}$ " diameter steel rod the bottom end of which fits into a tube socket cemented into the brickwork. A steel ring, also cemented into the brickwork, retains the upper end vertically.

Each door carries two steel loops welded on and they, with the rod, form the hinges. A ring handle on the upper door allows for the opening and closing of this part while the furnace is in operation. During the melt the lower door is wedged shut and forms the fourth wall to the melting area.



Forced draught from a portable blower is introduced into what may be called the ashpan. When the mouth of the blower is inserted the extra width of the opening is blocked off with a loose firebrick.

The doors themselves are each in the form of a rectangular steel frame bent up from 3" x 1/2" strip and welded. Each frame is rammed up as firmly as possible with a dampened mixture of fireclay and grog in a proportion of about fifty-fifty. They are allowed to air dry before a fire is lighted to burn them out. The simple grate is in the form of six 1/2" square iron bars spanning the ashpan and riveted to angle iron resting on ledges prepared in the brickwork.

The main feature of the furnace, however, is probably that of the use made of aggregate for insulation rather than solid brick. The brickwork is in two parts, the furnace proper built of refractory brick on the inside and a surrounding wall of ordinary brick to contain the insulation material. Firebrick is also used at the base of the flue where the heat is really intense; the rest of the chimney again is ordinary brickwork.

There is thus a cavity surrounding the melting zone and into this is poured the loose aggregate. This is in the form of crushed (soft) firebrick varying in size from dust to pieces about 10mm. It is allowed to remain as it falls and is not compacted in any way.

A cement mortar is used for the ordinary brickwork, but for constructing the refractory parts a special fire cement is employed. If you require further information about heat-resisting materials of this kind please refer to the Appendix which lists the names and addresses of a number of firms who are willing to supply modest quantities of foundry materials to the amateur.

The exposed ironwork of the furnace is

protected from the weather with grey, zinc-based paint which has proved very durable. The doors of the furnace can be removed for repair simply by withdrawing the 3/4" rod from its socket in the plinth. It is found in practice that the upper door suffers little in operation but some repair is needed from time to time to the lining of the lower door where the heat, of course, is greatest and actually tends to fuse the refractory material so that it runs in tears. The burnt stuff has to be chipped away and the hollow made good and levelled off with new clay.

Swinging doors of this kind are not unusual on furnaces. Sometimes they are arranged to open upwards against a back wall. But they do have one drawback – when the door is open for access to the crucible the operator is exposed to a terrific radiant heat. The situation is rendered comfortable by hanging a sheet of iron over the door as a shield.

The actual furnace aperture is a vertical space 8" x 9" x 20" high but the melting zone does not rise above the lower ten inches; within the confines of the space enclosed by the lower door. Refractory brick is expensive, so as much use as possible is made of common brick.

The chimney cover is a simple hinged flap. Basically a frame of angle-iron secured to the brickwork by means of four screws which are tapped into the angle and tightened on the brick. The cast iron balance weight seen in the photograph on page 79 serves to retain the flap in the open, vertical position.

Operation

This furnace has proved to be very effective and quite economical in service. It easily melts 10lb of iron at a time and this, of course, can be repeated several times in a session. It is reasonable to have as many moulds as possible ready for

pouring before firing up commences and then a minimum of heat is lost between melts. The residue in the pot, when it is returned to the furnace, can be added to immediately and the melting can almost be regarded as continuous. The number of times the melting can be repeated largely depends on the condition of the fire, which does tend to become fouled with ash and slag at each successive blow.

The weight of the crucible and metal added to the weight of the tongs puts a limit to the quantity that can be melted at one time. It is helpful to have a second person armed with a long iron bar to assist in taking some of the load at the moment of lifting. The same bar can give added support while the crucible is transferred to the mould for pouring. An alternative, of course, is to lift the crucible from the fire and place it in a double-handled ring shank for pouring.

It is acknowledged that, in the ordinary way, a weight of up to 10 lb cannot be regarded as considerable. But when this 10 lb is, in fact, molten iron at white heat on the end of a pair of heavy tongs and up to a yard away from the point of lift, even a strong man will waver!

Scrap iron is used for re-melting and this is broken into convenient sizes for charging into the pot. Each charge should be weighed beforehand to make sure that sufficient iron will be available to fill the mould in question. Some of this load may well protrude from the crucible and be piled on top of it. It sinks as the melt progresses. A small polythene bucket is useful for weighing out successive charges on a spring balance.

The composition of the scrap will not be known but iron with a fine grey fracture should be chosen. White iron is very hard and difficult to machine. The grain size of the scrap iron is not important but iron



which exhibits a white edge to the fracture is likely to be chilled and have a very hard skin. The chilling may indicate a deficiency in silicon. In any case it is always likely that the iron will lose more of its silicon in the re-melt.

The object of the whole operation is to produce castings in iron of good machinable quality and fortunately the lost silicon, which seems more than anything else to control the texture of the iron, can be made good by the use of a ladle alloy. The alloy comes as a granular grey material that can be obtained in packets of 4 oz. That is sufficient to inoculate 100 lb of iron or about 11 grams or under $\frac{1}{2}$ oz to 10 lb of iron. The silicon content can be increased still further if that is necessary by adding larger doses of the ladle alloy.

Crucible cast iron will be found to be of exceptionally fine grain. So fine, in fact,

that it can be machined to extremely thin sections in safety. As a case in point, miniature piston rings have been produced from it to a square section as small as .030". It will be found, in fact, to be a delight to work with. Ordinarily the sprue is broken or sawn off the casting and returned to the pot, but frequently it will be found possible to use this also for turning small parts. There is a good deal to be said on occasions for making the sprue of larger diameter than would actually be necessary specially to provide cast iron stick for turning. See the photograph of the locomotive cylinder casting in Chapter Five, page 55.

During melting a small quantity of crushed limestone or, alternatively, a proprietary brand of iron flux, can be added to the crucible. This is stirred into the top of the liquid iron and helps to bring up the slag which, prior to pouring and before the addition of the silicon, can be skimmed off. It is probably preferable to 'spoon' the slag away, where it can be tipped somewhere clear of the furnace. Unfortunately, well made steel or wrought

iron skimmers and ladles suffer badly in contact with the molten iron and often finish up by melting into the pot. The usual alternative is a wooden rake which, it is true, burns away, but it will allow the metal to be cleaned many times before it does. In successive melts, of course, the slag so removed does tend to foul up the furnace.

Oak and beech are suitable for making small rakes and stirrers and their use will have no deleterious effect on any of the metals referred to in this book.

Forced draught for this furnace, (see the photograph on page 86) is supplied by an electrically driven blower. The actual volume of air and the pressure it delivers is not known, but it has an impeller-type rotor 7" diameter by 2" wide. It is driven at 3,000 rpm by a universal mains motor of 40 watts. The body of this machine is mainly plastic and, as it appears in the photograph, it is mounted on a simple wooden stand incorporating an on-off switch. It is located far enough away from the furnace not to be subject to the effects of heat.

A high-speed blower resembling that of a large vacuum cleaner was tried for this furnace but it seemed to produce more pressure of air than volume. It was not, in fact, very successful.

However, a very useful type of blower, which has a good delivery of air is the car heater type of the kind illustrated in the photograph. This, of course, operates on only 12 volts so it is electrically safe and can conveniently be supplied from a battery charger of about 2 amps. If the battery charger has a controlled output, so much the better, as the speed of the blower can be regulated down to a tick-over to help in starting up the fire.

When dealing with molten metals of any kind it is a matter of sound common sense to wear some form of protection,



Asbestos mitts.



Even low melting-point alloys are difficult to handle without, at least, a stout pair of gloves. Leather has to be thick to be effective and it tends to burn and become hard and brittle, but asbestos mitts are not expensive.

More protection is essential when temperatures reach 2,000°F and above and, most particularly, for melting iron. In the matter of gloves or mitts, try to obtain the heaviest available. Those with leather inserts in double asbestos with a strong

lining are the sort to go for. Reasonably heavy boots or shoes should be worn. Summer sandals or carpet slippers are not the footwear for foundrymen!

Radiant heat can start a pair of trousers smouldering and the operator's knees suffer in consequence, so a heat-proof apron which, for preference, reaches almost to the floor is therefore indispensable. The example shown (home made) is of asbestos fabric with a cotton lining.

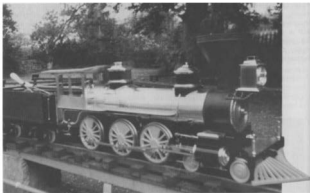
Protection for the eyes is also a matter



A car heater-blower provides excellent forced draught for a small furnace.

to be considered. If ordinarily glasses are worn, these at least will afford some insurance against accidental splashes, but a complete face mask would not be unreasonable. Tinted lenses are not really called for as the glare from the furnace is not so intense.

The worst example of splashing occurs when, in some way, water is introduced into the melt trapped in part of the scrap. Be cautious about damp bits of old packing and so on which may be adhering to cavities in the old metal.



The driving wheels for this American model are home cast. Dave Morris.



All castings for Blodwen by Joe Holdsworth.

APPENDIX

Useful Addresses of Suppliers of Foundry Materials and Accessories

British Foundry Units Ltd.
Retort Works
Chesterfield
Derbyshire

*Moulding boxes, fluxes, core dressings
binders, coaldust, sands etc.*

Fordath Ltd.
Brandon Way
West Bromwich
B70 8JL

No. 444 Cream for core making.

Foundry Services Ltd. and Jelaco Ltd.
Drayton Manor
Tamworth
Staffordshire B78 3TL

Fluxes, degassers for ferrous and non-ferrous alloys of all kinds as well as much useful help and advice freely given. Of particular value to schools.

D & J Hawkins
15 Woodland Grove
Tupton
Chesterfield
Derbyshire S42 6JQ

*Crucibles, plumbago, parting powder
canister, ferro silicon, tools and tongs.*

Mansfield Sand Co. Ltd.
Sandhurst Avenue
Mansfield
Nottingham NG28 4BE



A 2 hundredweight example from the backyard foundry.